

WJ-984
Microprocessor-Based
Temperature Controller
Instruction Manual



WATKINS-JOHNSON



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SECTION I

INTRODUCTION

1.0 INTRODUCTION (See Figure 1.1)

The WJ-984 is a 16-channel, stand-alone microprocessor based temperature controller for use in multizone temperature control applications. It is totally self-contained and is housed in a standard 19-inch rack-mount case.

All NBS listed thermocouples can be accommodated and all are linearized to provide high accuracy over the operating range.

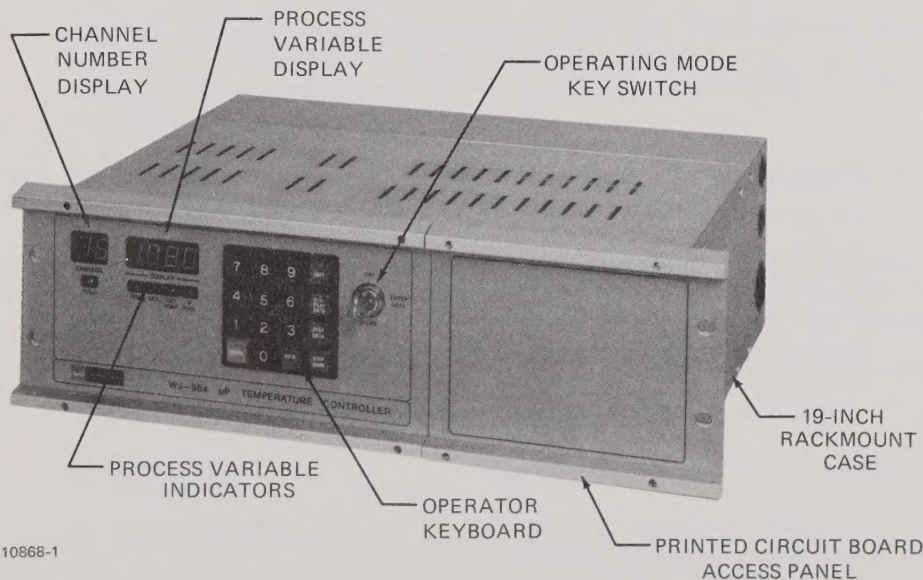
Outputs can be voltage, current or on-off time proportioning for direct drive of solid state relays.

Full tuning ability is provided for each channel with adjustable proportional band, reset and rate.

Control variables are entered through the front panel keyboard and displayed on the digital display. In addition, a key operated "scan" mode is provided which displays all pertinent parameters but prevents unauthorized changes.

Front access printed circuit boards allow quick troubleshooting and low down time.

An optional RS-232 port is available for serial communication with a variety of peripheral devices.



10868-1

Figure 1.1 - WJ-984 Controller

SECTION II

DESCRIPTION

2.0 DESCRIPTION

2.1 GENERAL

- 2.1.1 Inputs (See Figure 2.1) The WJ-984 accepts up to 16 thermocouple inputs. All standard NBS types are available and all are linearized to $\pm 1^{\circ}\text{C}$. Source resistance can be up to 1K ohm.

Cold junction compensation is provided by an Isothermal temperature sensing block located at the thermocouple connection terminals. Compensation is $\pm 1^{\circ}\text{C}$ over a 0 to 50°C change in ambient.

- 2.1.2 Outputs (See Figure 2.1) The following output types are available for all 16 channels:

- 1) 0 to 10 volts or 0 to 5 volts into a 1000 ohm or greater load
- 2) 4-20mA into a 0-700 ohm load
- 3) Open collector-time proportioning with 3 sec time base. Ideal for driving optically coupled solid state relays up to 40 Amps AC.

The output common terminals may be jumpered to either +15V or common to accomodate the various output types.

- 2.1.3 Control Variables and Tuning Constants. The basic WJ-984 controller features full "PID" (Proportional, Integral, Derivative) control. These terms are also called Proportional Band, Reset and Rate, respectively. (See Section 8 for complete description.)

Adjustment of these constants allow the operator to closely "tune" the controller response to match the response of the heating source.

Control variables are entered through the front panel keyboard in the "Enter Data" mode. Number of channels values are entered through coded switches behind the access panel. All variables are stored in a low power memory with 500 hrs. of Nicad battery backup in the event of power-failure.

The following constants may be selected for each channel:

- SETPOINT The desired operating temperature in $^{\circ}\text{C}$.
- MAX POWER A power limiting feature - regulates the maximum available power from 0 to 99%.
- PROPORTIONAL BAND Provides a linear relationship between temperature input and controller output - adjustable from 0 to 99°C around the setpoint.

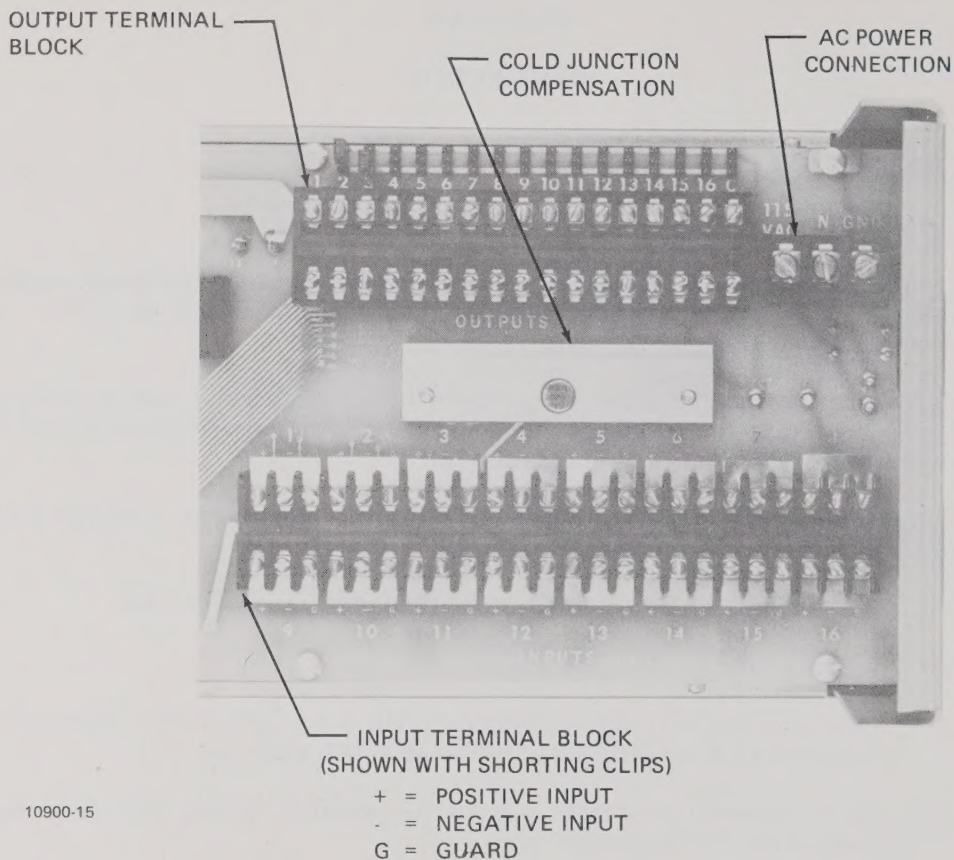


Figure 2.1 - Input-Output Connections

- HIGH AND LOW LIMITS Provides an upper and lower limit for process alarms. If either limit is exceeded, a SPDT relay is activated (one for low and one for high) and the controller displays a flashing "HL" or "LL" along with the effected channel number. Adjustable over the full range in $^{\circ}\text{C}$.
- RESET (Integral) The output is proportional to the time integration of the deviation between the temperature and setpoint. This action prevents offset in processes where frequent load changes occur. Adjustable from 0.0 to 9.9 REPEATS PER MINUTE. Anti-reset windup inhibits reset action to prevent overshoot when the temperature is outside the proportional band.

- RATE (Derivative)

The output is proportional to the rate of change of the input temperature. This action provides quick response to sudden changes or upsets in the process. It essentially changes the output before a significant deviation occurs. Adjustable from 0.0 to 9.9 minutes.

- NUMBER OF CHANNELS

Selects the desired number of operational channels. Adjustable from 1 to 16. Unselected channels are not scanned.

2.1.4 Serial Communication Option (See Figure 2.2) A serial port configured after EIA Standard RS-232-C is offered for direct communication with various peripheral devices such as:

- Line Printers
- CRT Terminals
- Modems
- Other computers
- Data Recorders



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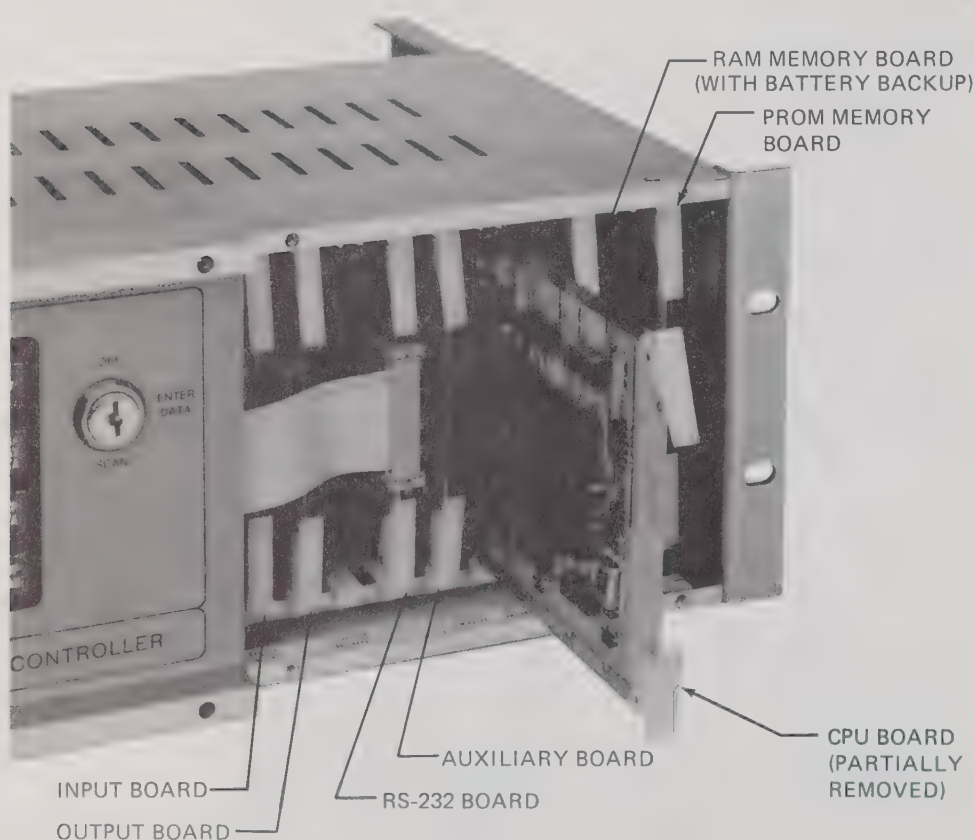
Figure 2.2 - RS-232 Connector

Various standard software packages are available or software can be customized to customer requirements.

RS-232 voltage levels or 20 mA current loop operation is available.

- 2.1.5 Service and Downtime (See Figure 2.3) To minimize downtime, the WJ-984 incorporates modular front entry PC boards that can be replaced in seconds.

In addition, spare boards kits are stocked at Watkins-Johnson for immediate shipment in the event of a problem.



10900-11

Figure 2.3 - PC Board Removal

2.2 PC BOARDS

The various PC boards are divided into modular functions to facilitate testing and repair. There are a total of 11 boards as listed below:

- CPU Board
- RAM Board
- PROM Board
- Input Board
- Output Board
- Front Panel Board
- Power Supply
- Auxiliary Board
- Backplane Board
- RS-232 Board (optional)
- Alarm Board

All boards plug into a common backplane board which distributes the power, data, address, and control busses. The following is a discussion of the boards and their functions:

2.2.1 CPU Board (See Figure 2.4) The CPU Board contains two 8-bit microprocessors operating in a master-slave configuration. Both processors share common memory and utilize the same address, data, and control busses. The "master" processor is responsible for the following tasks:

- Read A to D converter and store values in memory
- Multiplex inputs for the 16 channels
- Calculate outputs using a software control algorithm

The "slave" processor is dedicated to these tasks:

- Multiplex and update display
- Check keyboard and front panel keyswitch
- Interpret keyboard commands and execute appropriate response
- Service RS-232 port

A triple programmable timer (Intel 8253) can be set up in various modes by instructions from either CPU. It is programmed to provide the following clock signals:

- 62.5 kHz clock to the A to D convertor
- Programmable interrupt to slave CPU
- Programmable baud rate clock to RS-232 serial communication board. (110 to 9600 baud)

Various other components on the CPU board provide the necessary current drive for the address, data and control busses which terminate at the edge connector.

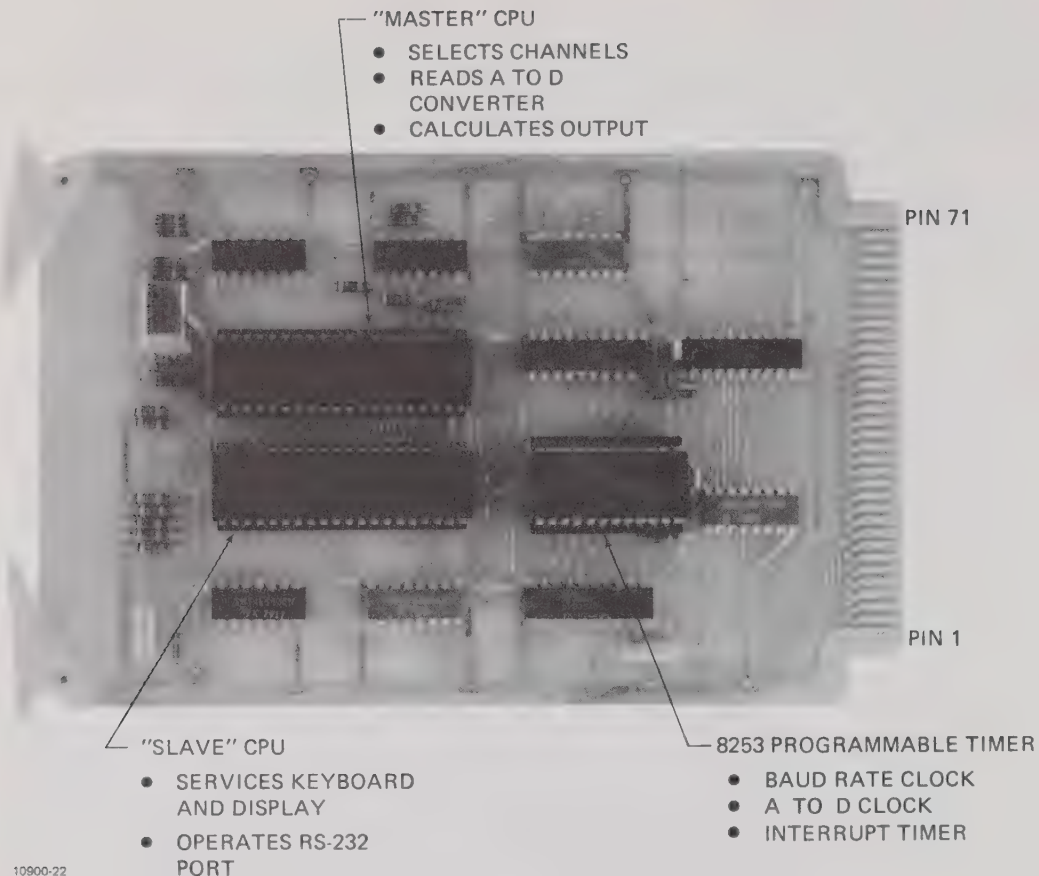


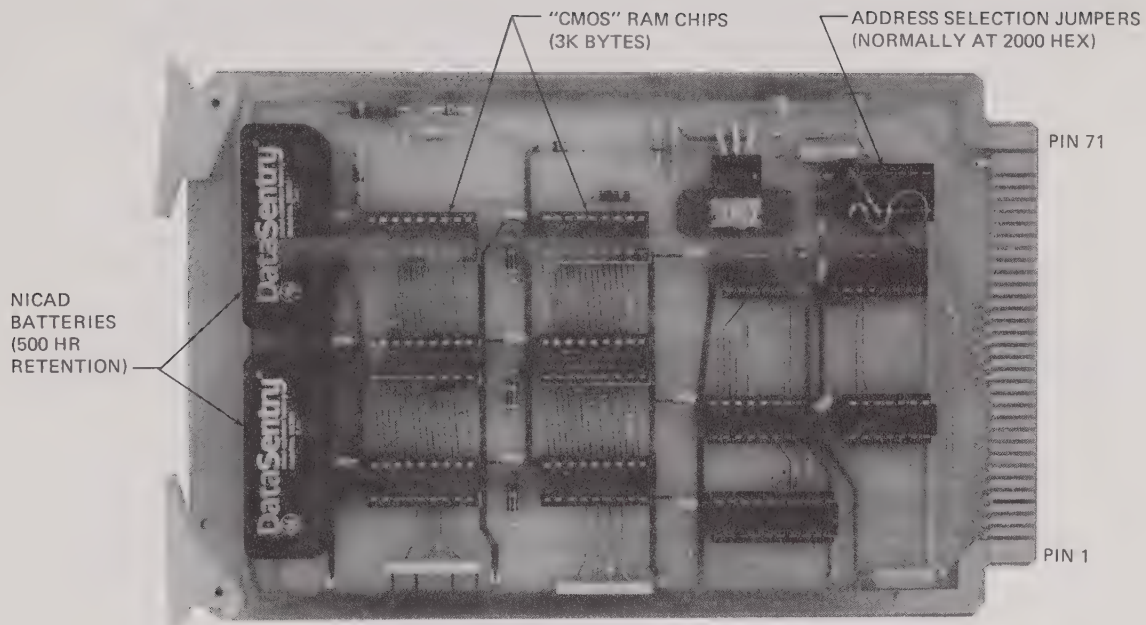
Figure 2.4 - CPU Board

2.2.2 RAM Board (See Figure 2.5) The RAM Board stores the various control parameters entered through the keyboard as well as the temperature and control data.

Low power CMOS RAMS (6514) provide 3072 Bytes of storage. Two nickel-cadmium batteries provide power to the memory in the event of a power failure and thus prevent loss of data. The batteries will provide up to 500 hrs. of retention from a fully charged condition. Batteries automatically charge when the power is on.

2.2.3 Prom Board (See Figure 2.6) The PROM board contains the memory chips for program storage. The master and slave processors "read" these chips to get their instructions.

The memory chips are the "EPROM" type meaning that they can be programmed and later erased with ultraviolet light. This allows the same chip to be used again for program changes. Two types of EPROM's can be used through jumper selection: The 2708 or 2716. The controller will accommodate up to two prom boards for a maximum memory size of 16,384 bytes (with 2716 EPROMS). Refer to Section 7 for PROM Board Jumper selection.



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Figure 2.5 - "RAM" Board

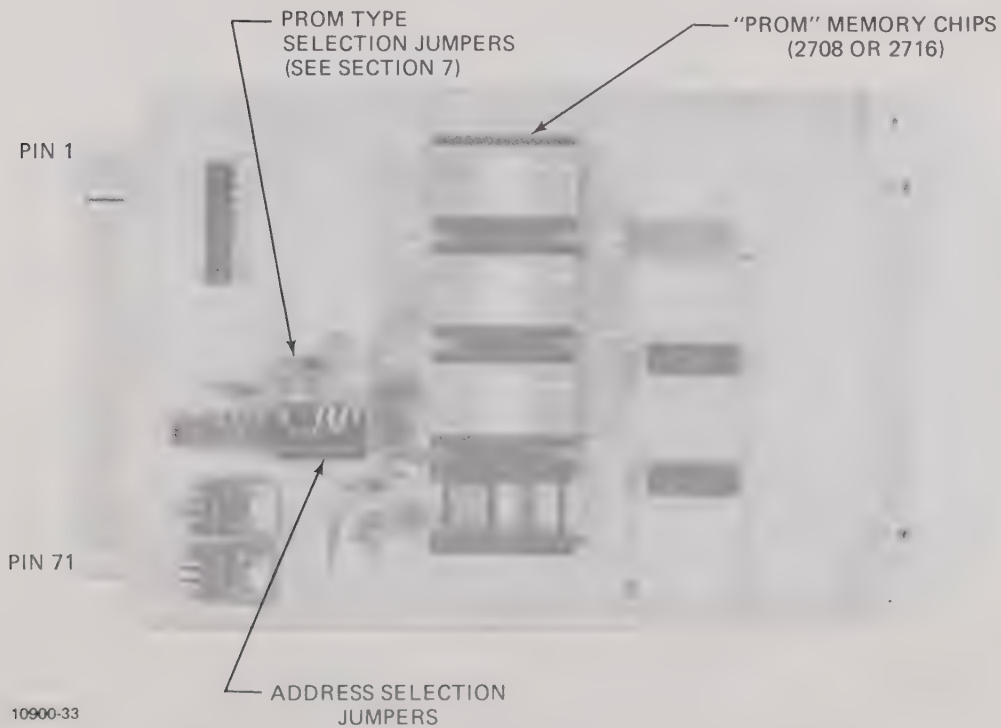


Figure 2.6 - "PROM" Board

2.2.4 Input Board (See Figure 2.7)

The Input Board provides the following functions:

- Selects 1 of 16 thermocouple inputs and connects it to a precision dc amplifier
- Amplifies the thermocouple signal to a higher usable level
- Sums the thermocouple signal with the cold junction compensation , the zero adjustment and the span adjustment
- Converts the summed signal to a digital signal through a BCD analog to digital converter
- Provides thermocouple break protection circuits

The Input Board has three trimpots located at the front of the board for calibration. These operate as follows:

- Zero - adjusts the zero or low end point (bias)
- Span - adjusts the range or high end span (gain)
- Reference - adjusted to 2.000 Vdc for A to D converter

For complete calibration instructions, see Section 5.

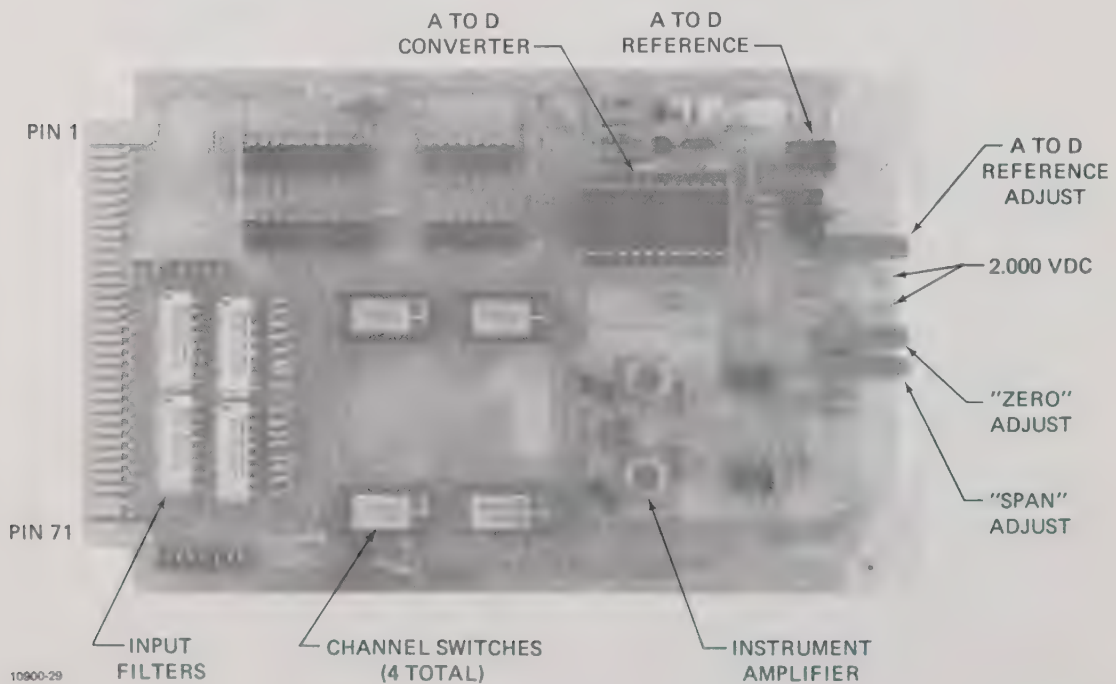


Figure 2.7 - Input Board

2.2.5 Output Board (See Figure 2.8) The output board converts the digital output from the microprocessor into an analog signal for driving a power controller. Three types of outputs are available:

- DC Voltage (0-5 Vdc, 0-10 Vdc)
- DC Current (4-20 mA)
- Open collector, on-off time proportioning

The output board operates as follows:

- The digital output for the current channel being processed is latched into a precision Digital to Analog convertor. The convertor outputs a proportional 0 to 10VDC signal.
- The analog voltage is switched into a sample and hold circuit for the channel being processed
- The sample and hold voltage is conditioned into a voltage, current or time proportioned signal and appears on the output terminal block.
- The cycle is repeated for the next channel (every 1/2 sec a new channel is processed)

Two trimpots located on the front edge of the PC board provides the following adjustments:

- SPAN - Adjusts the span of the output (i.e. 0-10v, 0-5v, etc.).
- ZERO - Adjusts the zero point or bias

For a complete explanation of calibration of the output board see Section 5.

2.2.6 Auxiliary Board (See Figure 2.9) The auxiliary board contains the switches necessary for setting the following functions:

- Number of channels used (1 to 16)
- Reset value (for all channels) 0 to 9.9 repeats per minute (only on early versions)
- Rate value (for all channels) 0 to 9.9 minutes (only on early versions)

Refer to figure 2.9 for switch locations and description.

On later controllers (with rate and reset values entered through the keyboard) the lower BCD switch sets the baud rate for the RS-232 interface.

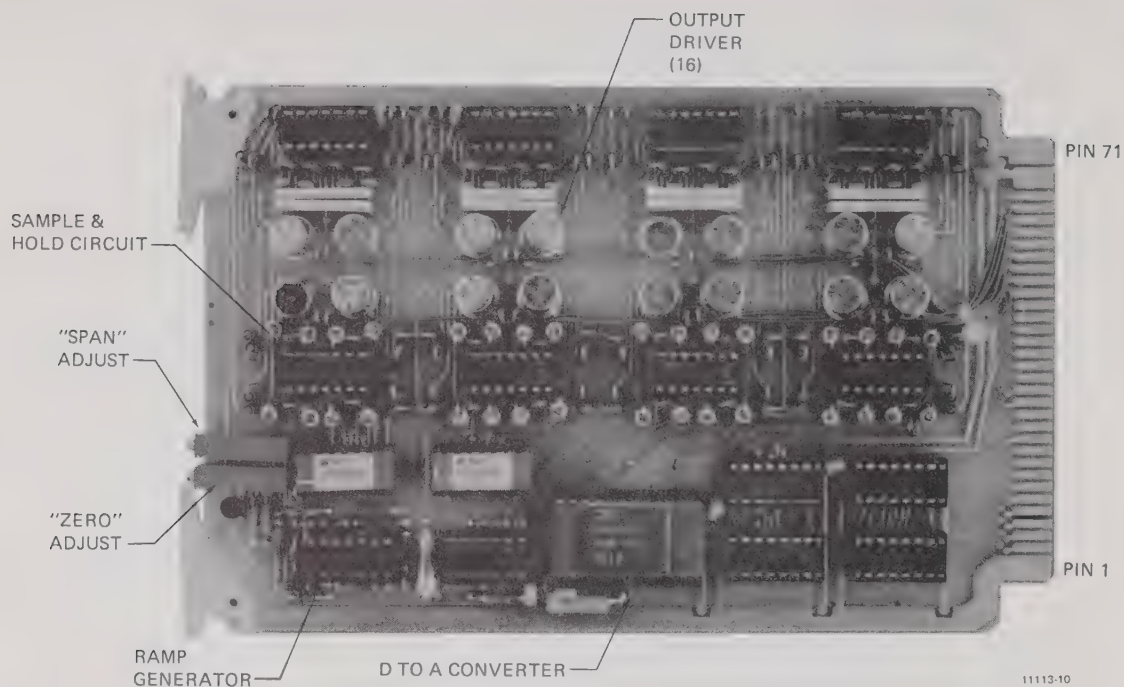


Figure 2.8 - Output Board

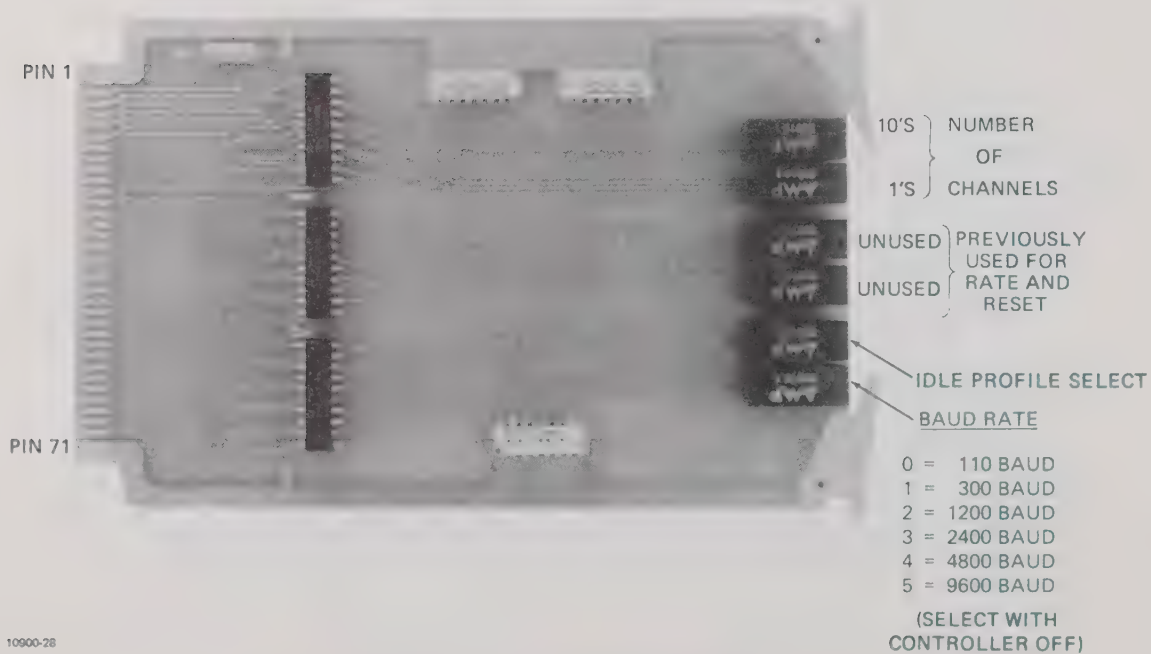


Figure 2.9 - Auxiliary Board

2.2.7 RS-232 Board (See Figure 2.10) The RS-232 board contains the logic necessary to provide an asynchronous serial interface patterned after EIA Standard RS-232C.

The Board contains a USART (Universal Synchronous/Asynchronous Receiver Transmitter) which is programmed to provide the following functions:

- Transmit ASCII characters from the processor at a predefined baud rate (110 to 9600)
- Receive ASCII characters at a predefined baud rate and present them to the processor
- Support various other RS-232 signals for handshake control

The transmitter-receiver chip may be configured as either a "Data Set" or "Data terminal". Refer to Section 6 for full details.

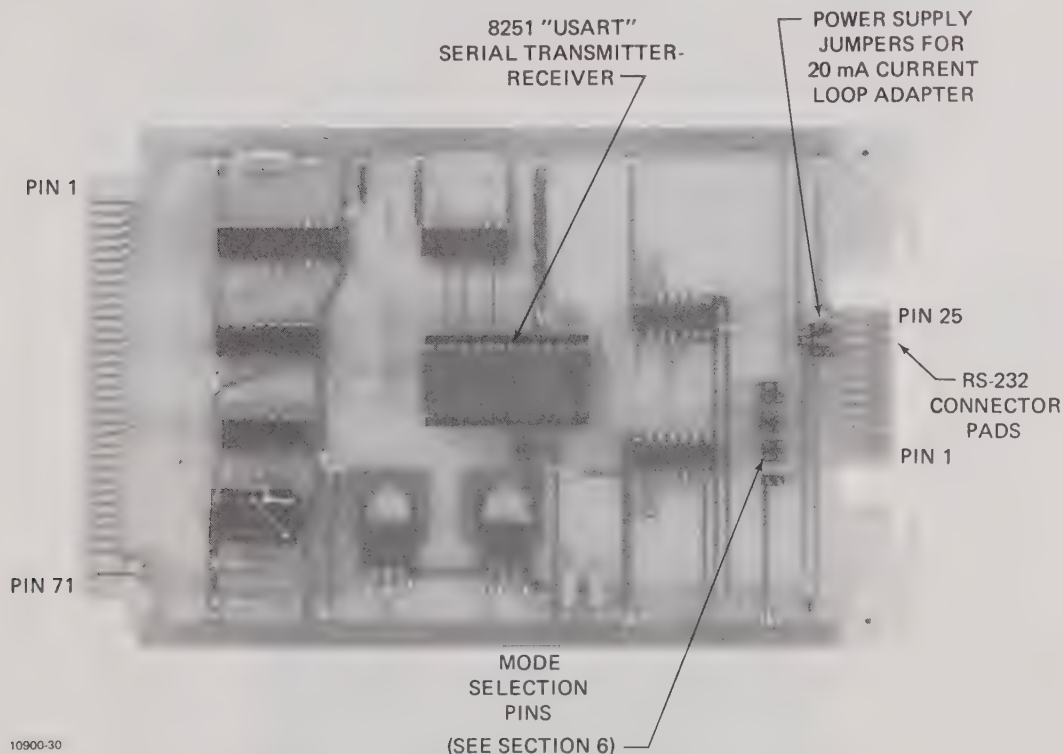


Figure 2.10 - RS-232 Board

2.2.8 Power Supply Board (Figure 2.11) The power supply board is located behind the keyboard-display panel. It is provided with a plug connection for quick and easy removal.

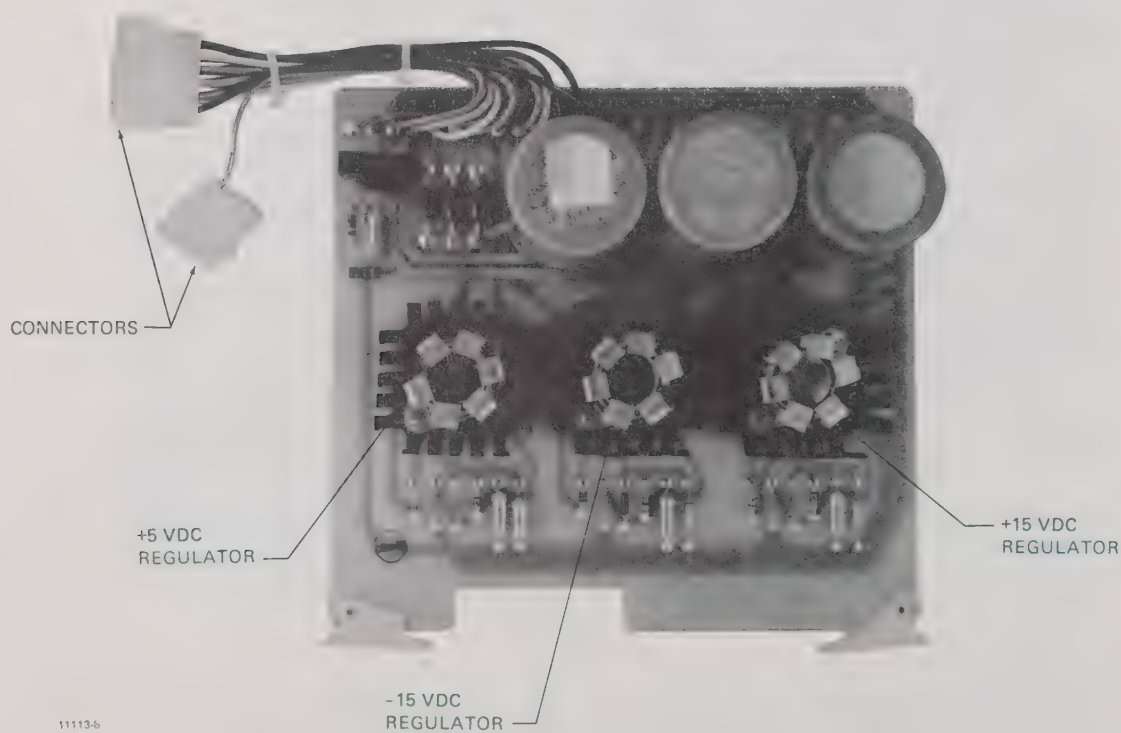
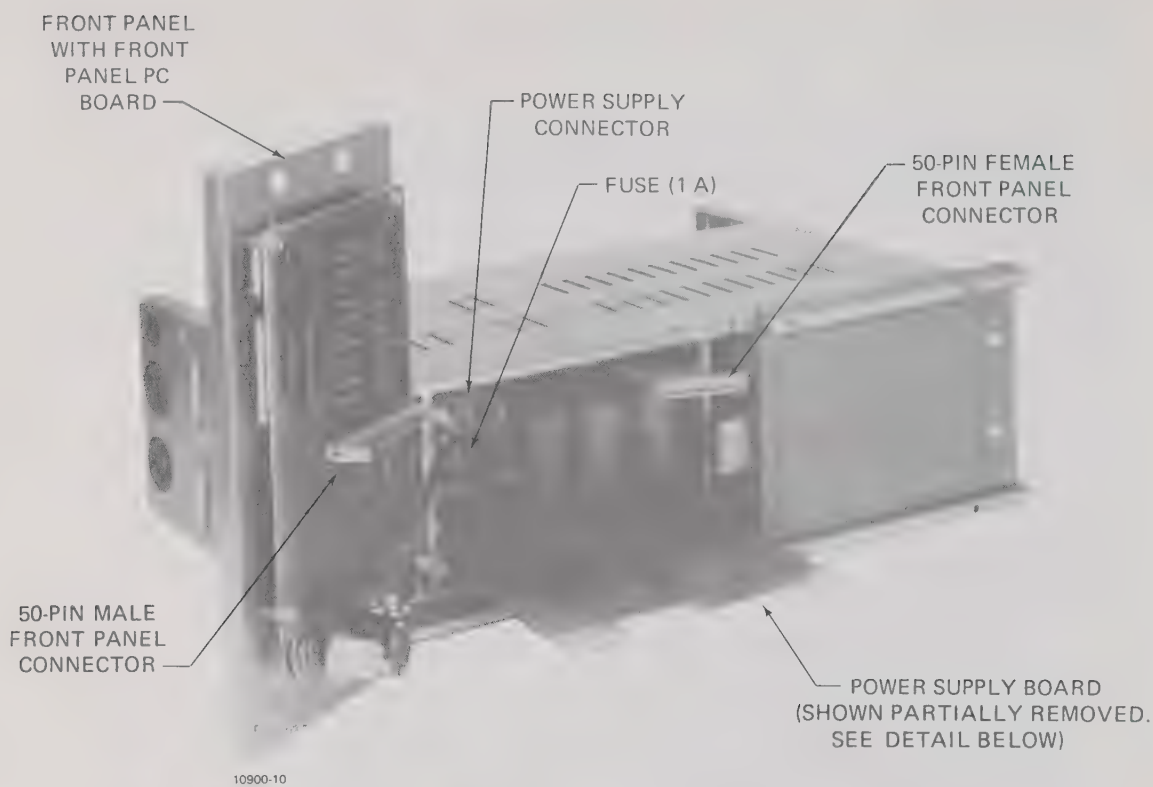


Figure 2.11 - Power Supply Board

The following voltages are supplied from the power supply to the busses on the backplane board: +5VDC, +15VDC and -15VDC (see 2.2.10 for backplane signal identification)

A 1 ampere fuse located behind the left front panel protects the power supply.

2.2.9 Front Panel Board (See Figure 2.12) The front panel board houses the keyboard and display plus the necessary logic to operate them.

A 50-pin plug-in ribbon cable connects the necessary signals from the backplane board to the front panel. (See Figure 2.11 for connector location)

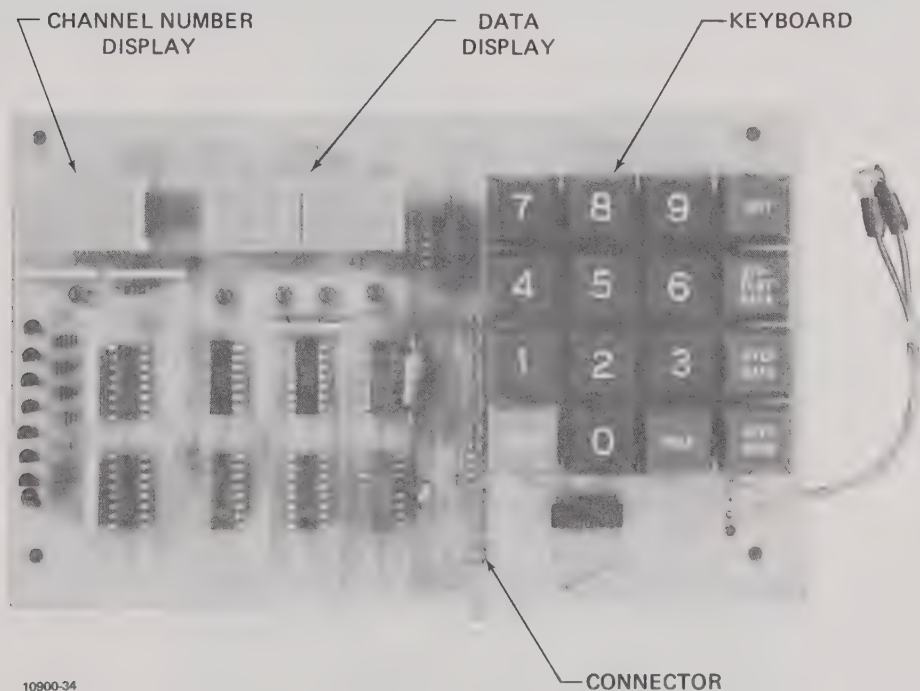


Figure 2.12 - Front Panel Board

2.2.10 Backplane Board (See Figure 2.13)

The backplane board mounts to the rear of the controller case and contains the following:

- Terminal Blocks for Input, Output and AC power connections
- Edge card connectors for bussing together the various temperature controller signals.
- Mounting pins for the alarm card.
- Cold junction compensation sensor

Table 2-1 lists the pin assignments for the backplane connector.

TABLE 2-1 BACKPLANE PIN ASSIGNMENTS

Connector 9 (Input)	Connector 8 (Output)	Connectors 1-7	Backplane Pins		Connectors 1-7	Connector 8 (Output)	Connector 9 (Input)
←	←	Dig. Gnd.	2	1	+5 VDC	→	→
←	←	Dig. Gnd.	4	3	+5 VDC	→	→
←	←	1 ↑	6	5	0	→	→
←	←	3 Data	8	7	Data 2	→	→
←	←	5 Bus	10	9	Bus 4	→	→
←	←	7 ↓	12	11	6	→	→
←	←	N Write	14	13	N Read	→	→
←	←	Reset	16	15	End of Conversion	→	→
←	←	A to D Clock 62.5 kHz	18	17	2 MHz Clock	→	→
←	←	Peripheral Select	20	19	Front Panel Sel.	→	→
←	←	Output Select #2	22	21	A to D Select #1	→	→
←	←	# of Chan Select	24	23	Output Select # 1	→	→
←	←	Rate Select	26	25	Reset Select	→	→
←	←	Baud Clock	28	27	Indicator Select	→	Cold Junction Pin 3
Cold Junction Pin 5	←	1 ↑	30	29	0	→	Cold Junction Pin 6
+ Inputs 1	←	3	32	31	2	→	- Inputs 1
2	←	5 Addr	34	33	Addr. 4	→	2
3	←	7 Bus	36	35	Bus 6	→	3
4	←	9	38	37	8	→	4
5	←	11	40	39	10	→	5
6	←	13	42	41	12	→	6
7	←	15 ↓	44	43	14	→	7
8	←	CPU 1 Flag 2	46	45	CPU 1 Flag 1	→	8
9	Output 1	LL Out	48	47	HL Out	Output 2	9
10	3	CPU 2 SB In	50	49	CPU 1 SB In	4	10
11	5		52	51	Pwr Fail	6	11
12	7		54	53		8	12
13	9		56	55		10	13
14	11		58	57		12	14
15	13		60	59		14	15
↓ 16	↓ 15		62	61		↓ 16	↓ 16
←	←	Analog Gnd.	64	63	Analog Gnd.	→	→
←	←	-15 VDC	66	65	+15 VDC	→	→
←	←	-15 VDC	68	67	+15 VDC	→	→
←	←	Dig. Gnd.	70	69	+5 VDC	→	→
←	←	Dig. Gnd	72	71	+5 VDC	→	→

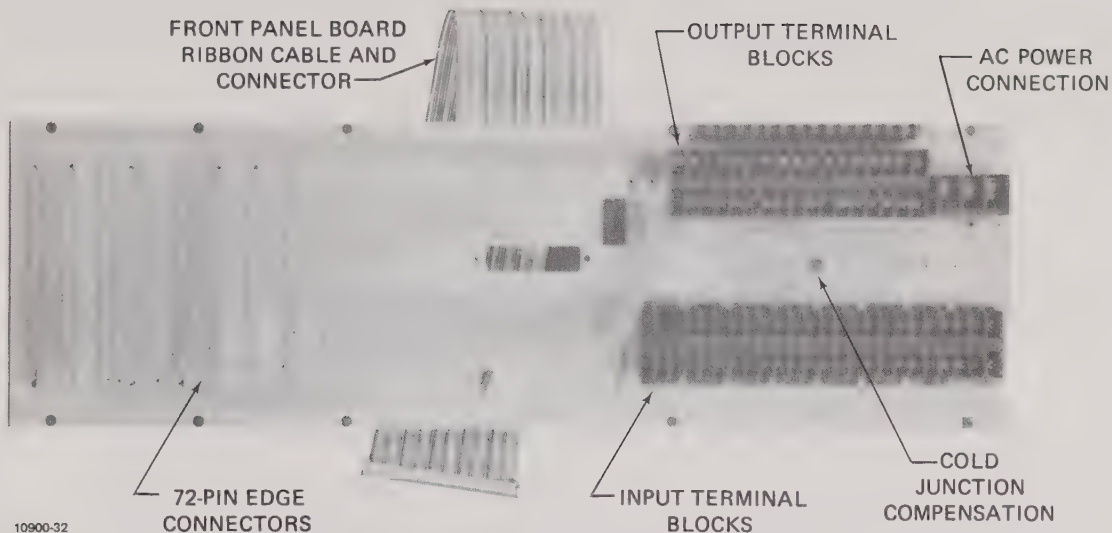


Figure 2.13 - Backplane Board

- 2.2.11 Alarm Card (See Figure 2.14) The alarm card contains two SPDT relays which are activated by the microprocessor in the event of a high or low limit alarm condition. A 6-pole terminal block is provided for customer connection. Figure 2-14 illustrates the pin functions.

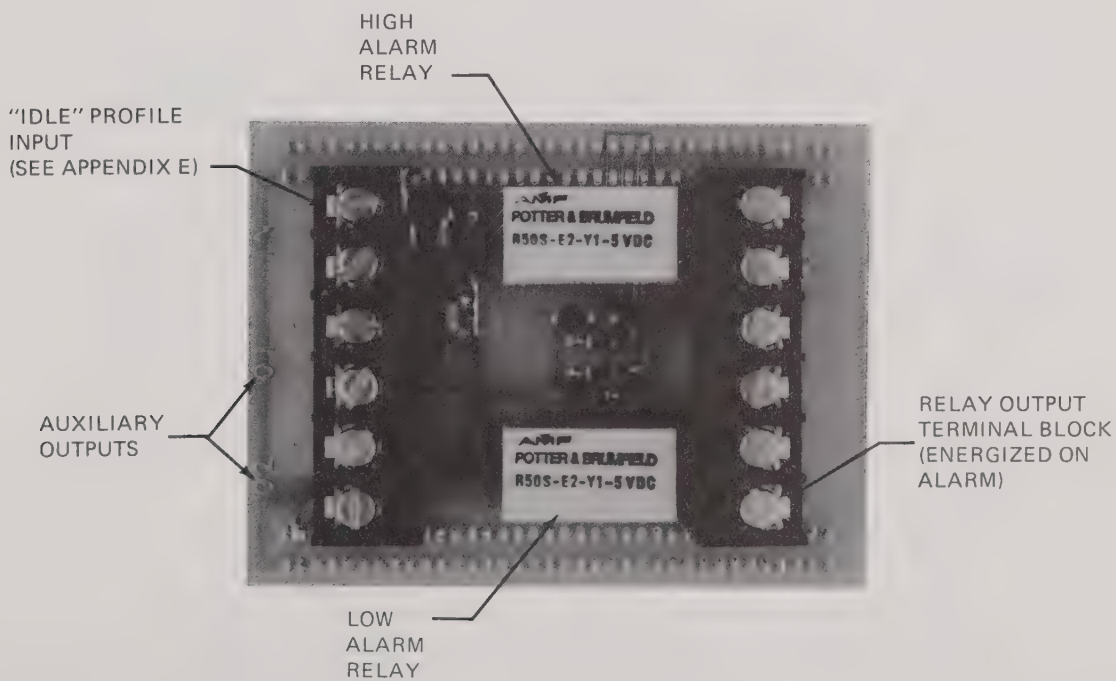


Figure 2.14 - Alarm Card

SECTION III

INSTALLATION

3.0 INSTALLATION

3.1 CASE MOUNTING

The WJ-984 case fits into a standard 19-inch wide rack-mount cabinet. Cutout and overall dimensions are shown in Figure 3.1. Four $\frac{1}{4}$ -20 pan head screws secure the controller.

3.2 AC POWER WIRING

Normal AC wiring is 115VAC, 50/60 Hz. (230VAC, 50Hz is optional and specially marked.)

Connect AC wiring as shown in Figure 3.2 to the 3-pole terminal block at the upper right hand side. This wiring is fused in the controller at 1 A.

3.3. THERMOCOUPLE CONNECTION

Two 24-pole terminal blocks are provided for thermocouple connection as shown in Figure 3.2. Normally a 3-wire extension cable is used with the two extension wires connecting to the + and - terminals and the drain wire connecting to the "G" or guard terminal.

Connect the thermocouples as shown in Figure 3.3. The fully guarded configuration is preferred for maximum noise immunity. Unused channels must have shorting jumpers for proper operation. (Even if they are not selected internally)

3.4 OUTPUT WIRING

Two 17-pole terminal blocks are provided for output wiring as shown in Figure 3.2. The bottom terminal block is the actual output while the upper terminals are the common return. The upper terminals can be connected to either signal common or +15V depending on the output type (See Table 3-1 and Figure 3-2).

Table 3-1

<u>Output Type</u>	<u>Jumper Connection</u>
Time proportioning (WJ-984-00)	+15 common (top position)
Current output (WJ-984-10)	+15 common (top position)
Voltage output (WJ-984-05 or 06)	Ground common (bottom position)

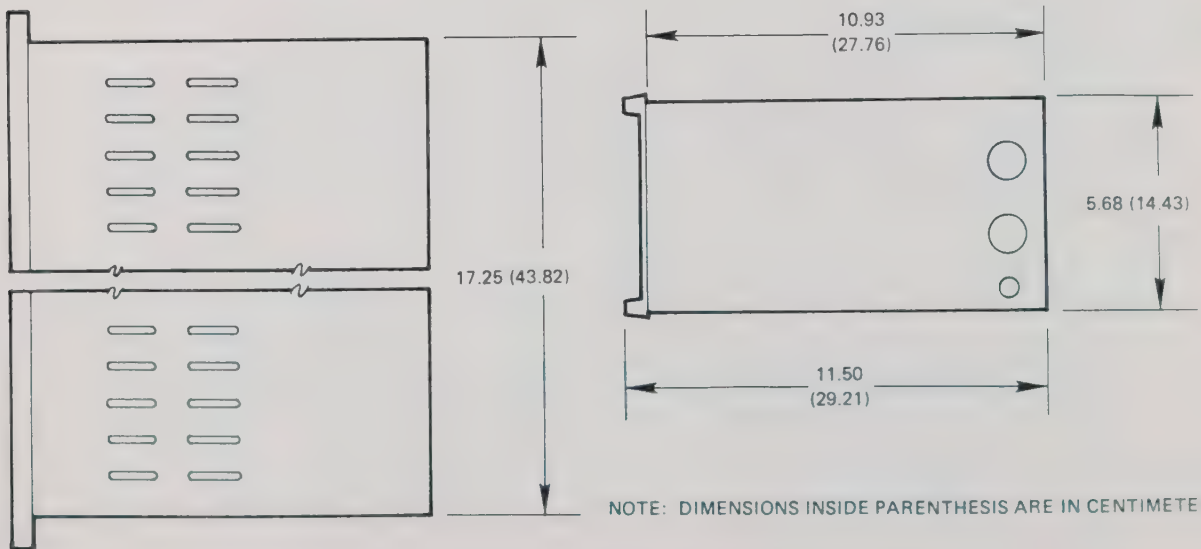
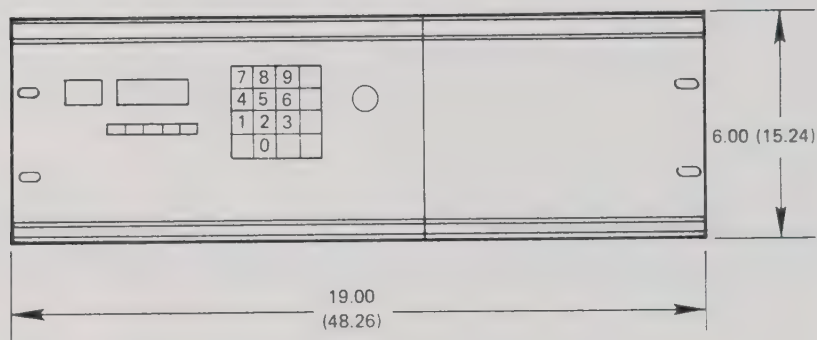
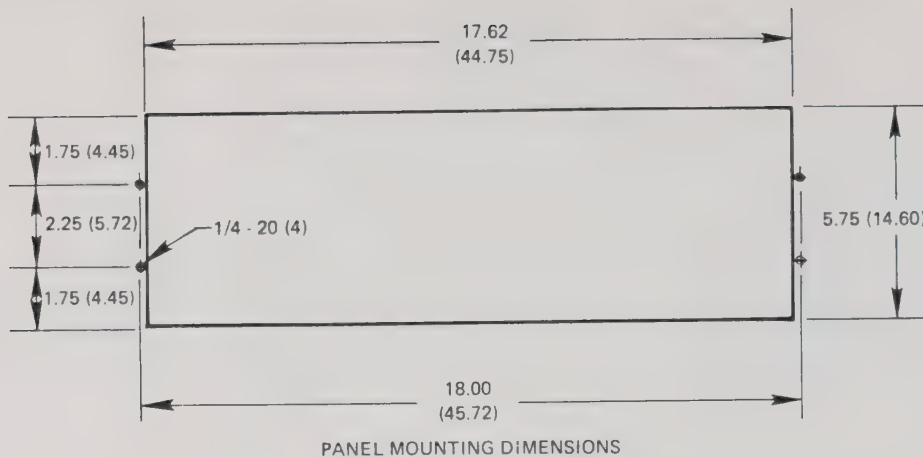


Figure 3.1 - Case Mounting Dimensions

COMMON TERMINAL JUMPERS

OUTPUT WIRING

COMMON
TERMINAL

OUTPUT
TERMINAL

+15 VDC COMMON
(TOP POSITION)

GROUND COMMON
(BOTTOM POSITION)

AC WIRING

115 VAC HOT
(BLACK)

NEUTRAL
(WHITE)

EARTH
GROUND
(GREEN)

SIGNAL
GROUND

THERMOCOUPLE
WIRING

(SHOWN WITH
SHORTING
JUMPERS—
UNUSED
CHANNELS
MUST HAVE
JUMPERS)

GUARD
(CONNECTED
TO NEGATIVE
SIDE OF
THERMO-
COUPLE

+ THERMO-
COUPLE
INPUT

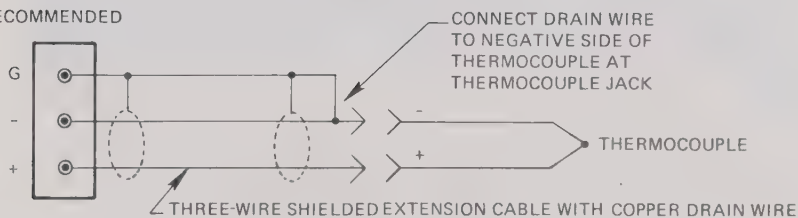
- THERMO-
COUPLE
INPUT

10900-15

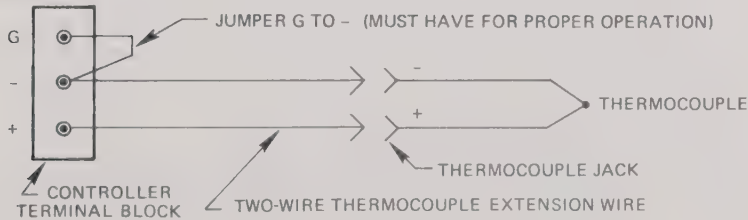
Figure 3.2 - Wiring Connections

INPUTS

A. RECOMMENDED

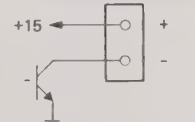


B. ADEQUATE

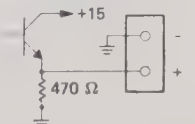


OUTPUTS

A. TIME PROPORTIONING



B. VOLTAGE OUTPUT



C. CURRENT OUTPUT

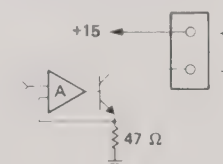


Figure 3.3 - Thermocouple Wiring

3.5 HIGH-LOW ALARM WIRING

The high-low alarm card is shown in Figure 3-4. The appropriate relay is activated in the event the preset high or low limit is exceeded.

A six-pole terminal block provides the common, normally open, and normally closed terminals as shown.

Relay rating is 1 A at 28VDC or 0.5 A at 120VAC resistive.

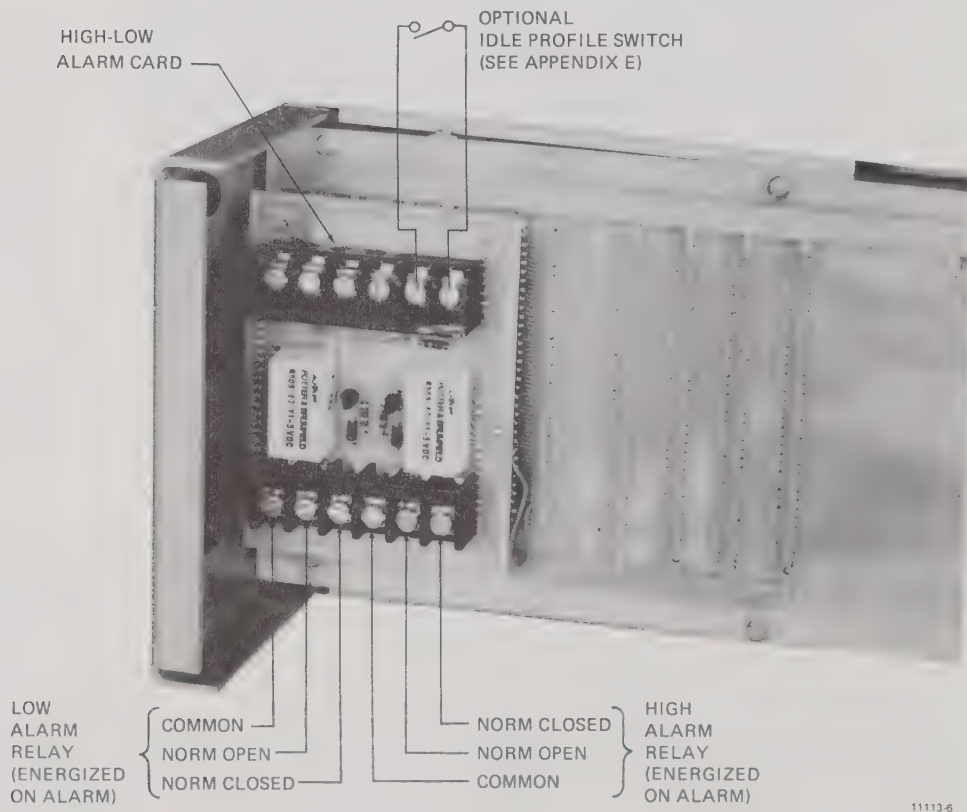


Figure 3.4 - High-Low Alarm Wiring

3.6 RS-232 CONNECTOR (See Figure 3.5)

The RS-232 serial connector (if ordered) exits at the bottom rear of the case. The connector is a standard 25-pin female "D" connector. Refer to Section 6 for full details on the RS-232 Jumper Configurations.



10900-12

Figure 3.5 - RS-232 Serial Connector

SECTION IV
OPERATING INSTRUCTIONS

4.0 OPERATING INSTRUCTIONS

Two basic operating modes can be selected by the key operated front panel switch:

4.1 ENTER DATA MODE (See Figure 4.1)

This mode allows entry of the various process variables by the use of the numeric keyboard and function keys.

A series of visual prompts notifies the operator as to what data is to be entered. The operator keys in the numerical value, depresses the "enter" key and the next prompt appears. The various prompts appear in the following order:

CH	-	Channel Number	HL	-	High Limit
SP	-	Setpoint	LL	-	Low Limit
PP	-	Maximum Power	I	-	Integral
Pb	-	Proportional Band	d	-	Derivative

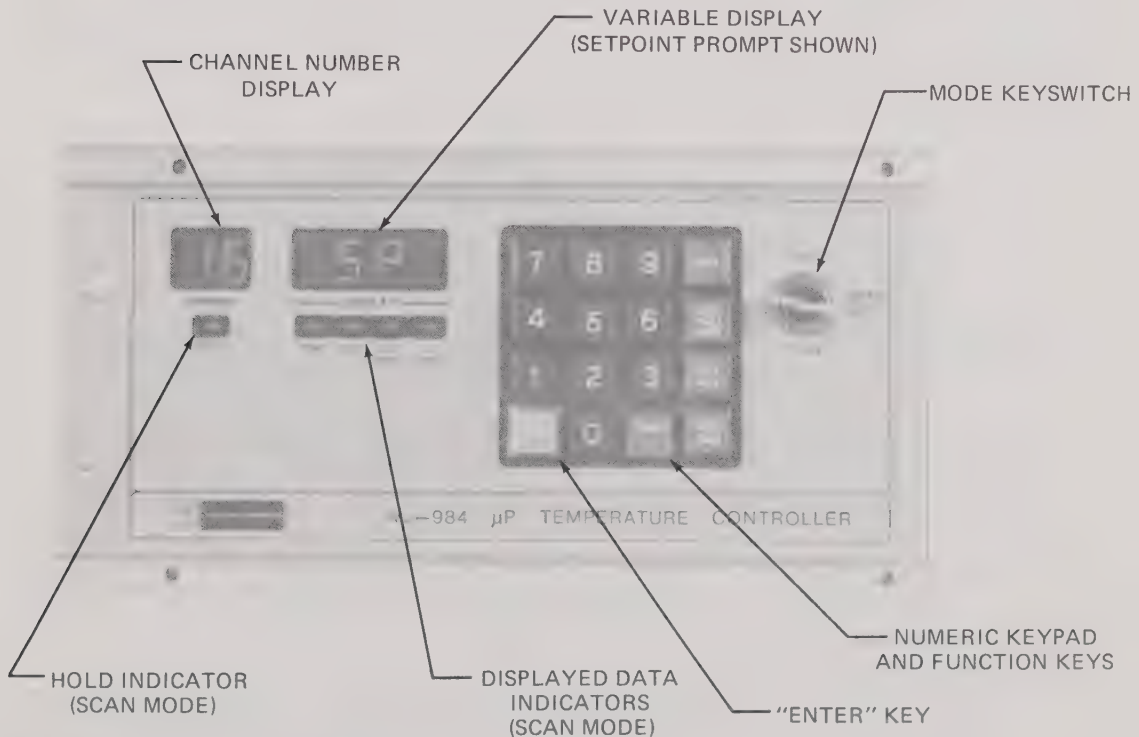


Figure 4.1 - Front Panel

Various function switches provide flexible operation and function as follows:

STEP DATA	Steps to next visual prompt in the order given above.
STEP CHANNEL	Steps to next channel and displays "SP" Setpoint prompt.
DISPLAY DATA	Provides 3 sec display of the current data value in memory for the corresponding channel number and prompt shown.
INITIALIZE ("FUNCTION" on later versions)	Returns to the "CH" prompt asking for a new channel number. Also used to select other option functions. (See Appendix)
ENTER	Enters to memory the value currently keyed in on the display then automatically displays the next prompt. Refer to Figure 4.2 for "ENTER DATA" examples.

4.2 SCAN MODE

The second key switch position activates the "scan mode" of operation. This mode allows the operator to read important control variables, but in this mode variables cannot be altered. Normally the key is removed in this position to prevent unauthorized data changes.

Four variables can be displayed in scan mode:

- Temperature ($^{\circ}\text{C}$)
- Deviation from Setpoint ($^{\circ}\text{C}$)
- Setpoint ($^{\circ}\text{C}$)
- Output Power (%)

Each channel is scanned at a 3 sec interval to display the selected process value. Four indicator "Leds" tell which variable is currently being displayed.

In addition the following 3 key switches provide added flexibility:

- Step Channel Key - skips to the next channel without waiting for the 3 sec scan interval.
- Step Data Key - selects the next process variable for display from the above four. Indicator lights to tell which variable is being displayed.
- Hold - depressing the "Hold" key stops the scan on the current channel for monitoring, and activates an indicator to signify the hold state. Depressing the key again releases the hold state and the scan continues.

If line power is lost in the "Scan" mode of operation, all entered variables are protected up to 500 hours by the battery backup circuit on the RAM memory board. Note that this is only true in the "SCAN" mode.

EXAMPLE 1 – CHANGE ALL VARIABLES IN A GIVEN CHANNEL

SELECT CHANNEL 10 AND CHANGE:

SET POINT TO 1075°C

LOW LIMIT TO 1050°C

MAXIMUM POWER TO 80%

RESET TO 0.3 REPEATS PER MINUTE

PROPORTIONAL BAND TO 30°C

RATE TO 1.0 MINUTES

HIGH LIMIT TO 1100°C

<u>PRESS:</u>		<u>SEE DISPLAYED</u>	<u>REMARKS</u>
KEYSWITCH TO "ENTER DATA"	→	CH	CHANNEL NUMBER PROMPT
10 ENTER	→	10 SP	SETPOINT PROMPT APPEARS
1075	→	10 1075	1075°C SETPOINT TO MEMORY
ENTER	→	10 PP	MAXIMUM POWER PROMPT APPEARS
80	→	10 80	80% MAXIMUM POWER TO MEMORY
ENTER	→	10 Pb	PROPORTIONAL BAND PROMPT APPEARS
30	→	10 30	30°C PROPORTIONAL BAND TO MEMORY
ENTER	→	10 HL	HIGH LIMIT PROMPT APPEARS
1100	→	10 1100	1100°C HIGH LIMIT TO MEMORY
ENTER	→	10 LL	LOW LIMIT PROMPT APPEARS
1050	→	10 1050	1050°C LOW LIMIT TO MEMORY
ENTER	→	10 I	INTEGRAL (RESET) PROMPT APPEARS
3	→	10 3	0.3 R/M RESET TO MEMORY
ENTER	→	10 d	DERIVATIVE (RATE) PROMPT APPEARS
10	→	10 1.0	1.0 MINUTE RATE TO MEMORY
ENTER	→	11 SP	SETPOINT PROMPT FOR NEXT CHANNEL APPEARS

Figure 4.2 - "Enter Data" Examples

EXAMPLE 2 – CHANGE SELECTED VARIABLES FOR TWO CHANNELS

CHANNEL 8: STARTING AT "CH" PROMPT

DISPLAY EXISTING PROPORTIONAL BAND OF 60°C

CHANGE PROPORTIONAL BAND TO 35°C

CHANNEL 10:

DISPLAY EXISTING HIGH LIMIT OF 1150°C

CHANGE HIGH LIMIT TO 1160°C

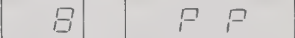
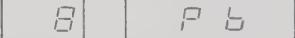
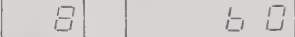
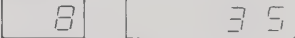
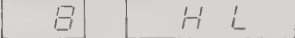
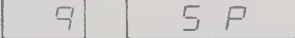
<u>PRESS:</u>	<u>SEE DISPLAYED:</u>	<u>REMARKS:</u>
8	 → 	SETPOINT PROMPT
	→ 	SKIP TO MAXIMUM POWER PROMPT
	→ 	SKIP TO PROPORTIONAL BAND PROMPT
	→ 	CURRENT PROPORTIONAL BAND DISPLAYED FOR 3 SECONDS
35	→ 	CHANGE PROPORTIONAL BAND TO 35°C
	→ 	35 TO MEMORY, NEXT PROMPT APPEARS
	→ 	STEP TO CHANNEL 10
	→ 	
  	→ 	PUSHING "STEP DATA" 3 TIMES SKIPS TO HIGH LIMIT PROMPT
	→ 	DISPLAYS CURRENT HIGH LIMIT FOR 3 SECONDS
1160	 → 	1160 TO MEMORY, LOW LIMIT PROMPT APPEARS

Figure 4.2 - "Enter Data" Examples (Cont.)

SECTION V

TROUBLESHOOTING AND CALIBRATION

5.0 TROUBLESHOOTING AND CALIBRATION

5.1 TROUBLESHOOTING

Since the Temperature Controller is a sophisticated software-controlled instrument, the type of indications observed for a given malfunction may appear to be totally unrelated to the actual cause of the malfunction. It is for this reason that the circuit boards were designed as individual modular functional units, which allows troubleshooting to be simply a matter of replacing boards until the controller is again functional. Watkins-Johnson maintains fully tested replacement boards for this purpose. In critical cases where no down time can be tolerated, spare boards should be maintained by the customer. (See spare parts list - Section 10).

The following is a recommended trouble shooting procedure:

1. Remove rear cover and verify that the power supply voltages are as shown in Figure 5-1.

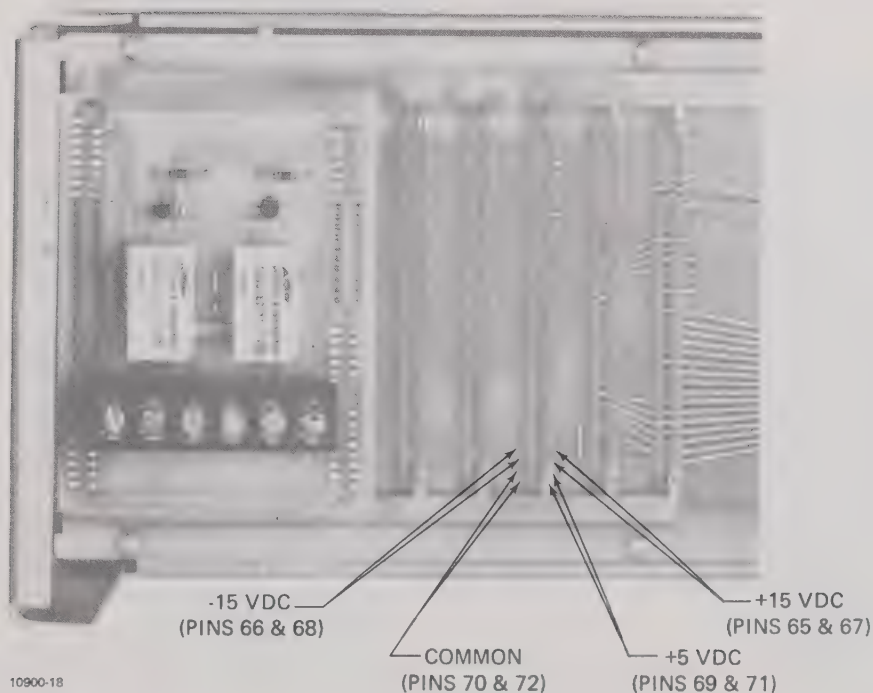


Figure 5.1 - Power Supply Voltages

2. If any of the supply voltages are not present, remove the PC board access panel (right side) and remove all the PC boards
3. Check the power supply voltages again. If the voltage is still absent the power supply is probably bad and is replaced as shown in Figure 5-2.
4. If the instrument is totally dead (i.e. - no power supply voltages present) check the fuse behind the keyboard panel (see figure 5-2). Replace with 1A medium acting.
5. If power supply voltages are correct, replace PC boards. Then exchange one board at a time with a good board until the problem is isolated.
6. The Front Panel circuit board is replaced by removing the keyboard front panel (4 screws) and disconnecting the 50-pin ribbon cable. The circuit board is held in place with four nuts, one each corner. Be sure to replace the ribbon connector in the same position (not inverted).
7. Faulty circuit boards can be returned to Watkins-Johnson for repair.
8. If the Input board is replaced, recalibration will be necessary. Refer to Section 5.2. With no recalibration, maximum error is about $\pm 5^{\circ}\text{C}$.
9. Always include the controller model number when ordering spare boards.

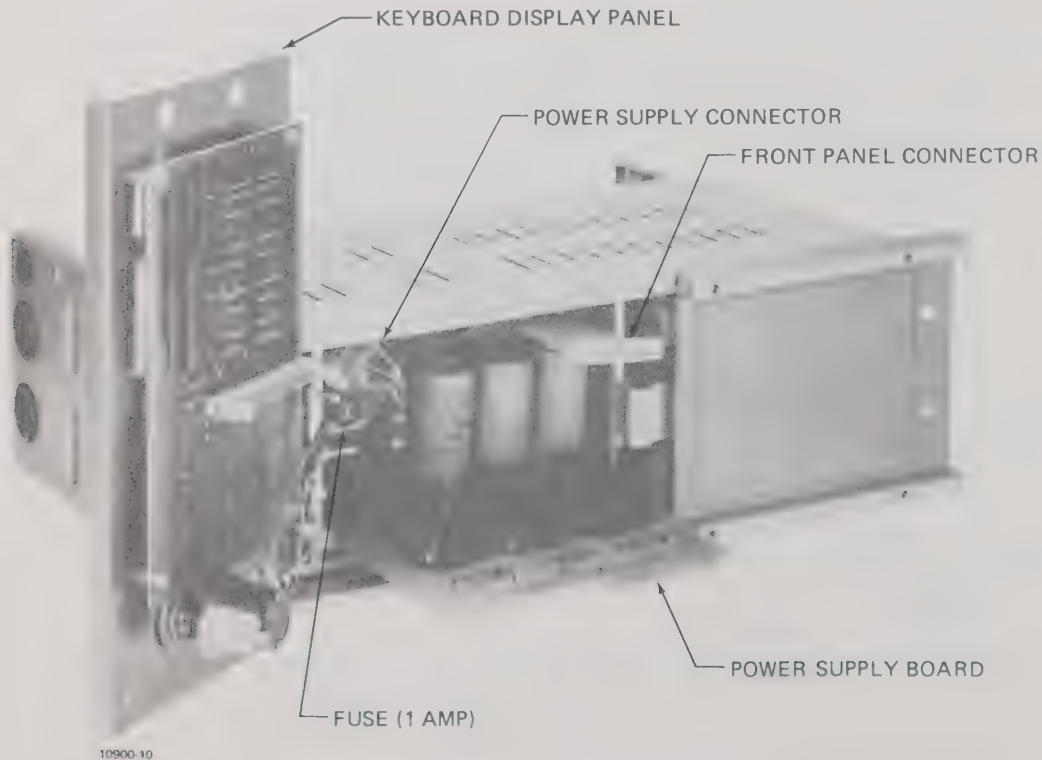


Figure 5.2 - Power Supply Replacement

5.2 CALIBRATION

- 5.2.1 Input Board Calibration. Refer to Figure 5.3. Calibration of the Input Board is recommended whenever the board has to be replaced. The following procedure is recommended:

EQUIPMENT NEEDED:

1. Fluke model 2190A digital thermometer with Y2003 calibrator or equivalent
2. Digital V-O-M

CALIBRATION INSTRUCTIONS

1. Allow controller to warm up for at least $\frac{1}{2}$ hour.
2. Remove right front panel to expose circuit boards and locate the input board. (See label at bottom of boards).
3. Referring to Figure 5.3, adjust the "Reference Adjust" pot to obtain a reading of 2.000VDC at the "+" and "-" test points.

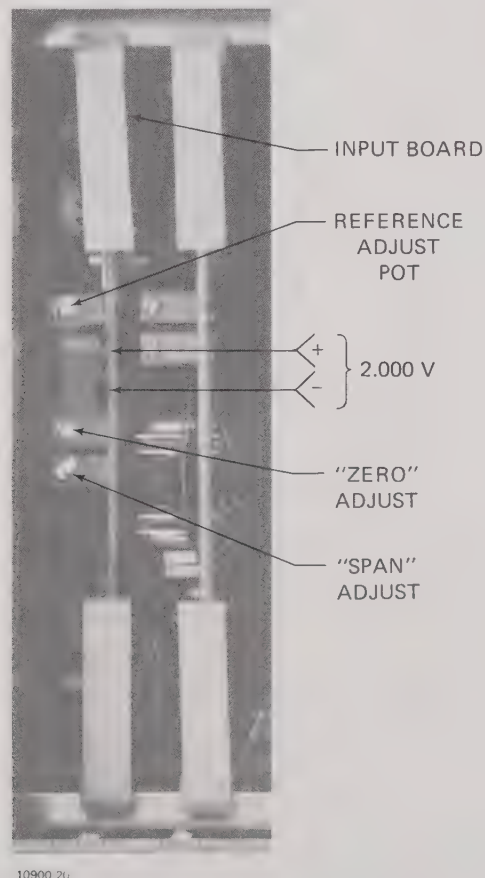


Figure 5.3 - Input Board Calibration

4. Connect the Fluke Calibrator (or another suitable MV source) to channel 1 of the input TB. Set the Key Switch to "SCAN" mode, channel 1, "HOLD" mode with temperature displayed.
5. Adjust the "zero" pot and the "SPAN" pot until the values shown in Table 5-1 are displayed with the MV inputs shown. Several adjustments are usually necessary.

Table 5-1. Span and Zero Calibration Values

Thermocouple Type	"ZERO" Input Value	"SPAN" Input Value
Type "K"	50°C(2.02mV)	1100°C(45.11mV)
Type "R"	300°C(2.40mV)	1650°C(19.53mV)
Type "S"	300°C(2.32mV)	1650°C(17.36mV)
Type "J"	25°C(1.28mV)	600°C(33.096mV)

NOTE: MV values are referenced to 0°C. Subtract ambient mV value for sources not referenced to 0°C.

- 5.2.2 Output Board Calibration. Refer to Figure 5.4. Two types of output boards may be used: time proportioning or current/voltage.

The time proportioning type has a 3-second time base and determines power by the on to off ratio. For example, 75% power would be on for 75% of 3 seconds and off for 25% of 3 seconds.

The current/voltage type has outputs of 0 to 5V, 0 to 10V, or 4-20mA depending on jumper setup.

The following steps are recommended for calibration:

1. Allow controller to warm up for a minimum of 10 minutes.
2. Remove the PC board access panel and locate the output board.
3. Connect a VOM to the output for channel 1 and set the maximum power for channel 1 to zero.
4. Adjust the "zero" pot until there is a slight output and then back it off $\frac{1}{4}$ turn.
5. Adjust the output for channel 1 to 99% and adjust the "SPAN" pot until the output shows full on (i.e., 5 volts, 10 volts, 20mA, etc., depending on output type).
6. Calibration of other channels is not necessary.

7. Replace PC board access panel and set maximum power setting for channel 1 to desired value.

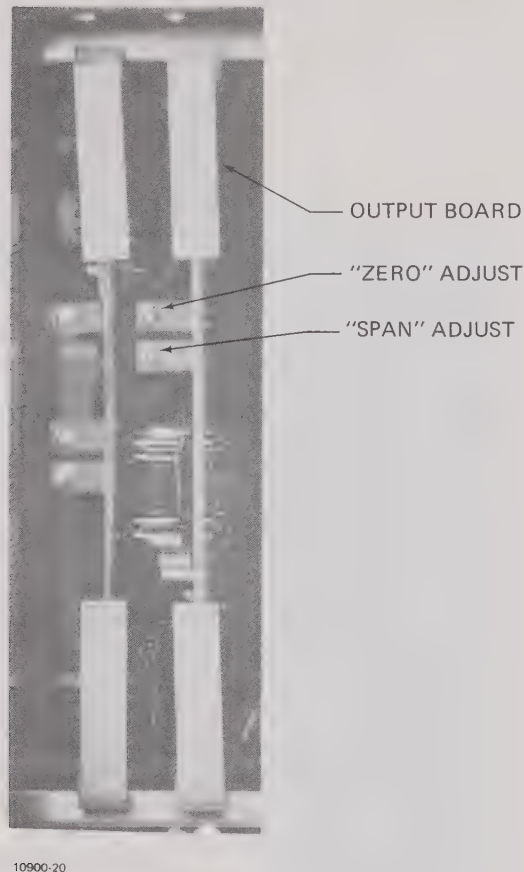
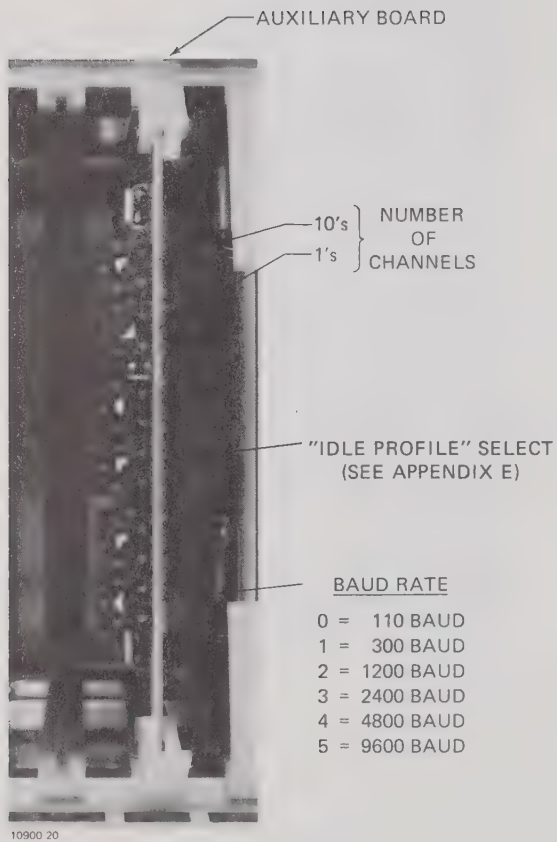


Figure 5.4 - Output Adjustments

5.2.3 Number of Channels Adjustment. The number of channels that are scanned may be selected by two BCD switches located behind the PC board access panel. The following steps are recommended:

1. Remove the PC access panel and turn the controller power off.
2. Locate the "number of channels" switches as shown in Figure 5.5
3. Adjust the switches with a small screwdriver for the desired number of channels. (1 to 16). The top switch is 10's; the bottom switch is 1's.
4. Replace PC board cover and turn controller on.

5.2.4 Baud Rate Adjustment. On controllers equipped with the RS-232 serial communication interface (option 010), the Baud rate may be selected as shown in Figure 5.5. Power to the controller must be off, since this switch is only read when the instrument is initially turned on.



SECTION VI
RS-232 SETUP

6.0 RS-232 BOARD SETUP

6.1 JUMPER CONNECTIONS

The RS-232 Board can be configured as either a "Data Set" or "Data Terminal" via on-board jumpers. Jumper pins are numbered and can be connected by wire wrapping or with Berg "PV" jumpers. Table 6-1 shows jumper connections.

Table 6-1. Jumper Connections

Signal	for Data Set Connect	forData Terminal Connect
Transmitted Data	1 to 2	2 to 4
Received Data	3 to 4	1 to 3
Data Terminal Ready	9 to 10	10 to 12
Data Set Ready	11 to 12	9 to 11
Request to Send (Note 1)	5 to 6 17 to 8	6 to 8 17 to 18
Clear to Send (Note 1)	7 to 8 15 to 16	5 to 7 15 to 16
Protective Ground	13 to 14	13 to 14
+12V and -12V for TTY current loop adapter	21 to 22 20 to 19	21 to 22 20 to 19

NOTE 1: If "Request to Send" and "Clear to Send" are not used, Jumper 16 to 18.

6.2 CONNECTOR PIN IDENTIFICATION

The RS-232 signals interface through a 25-pin "D" Type connector located behind the rear access cover. The pin identification is shown in Table 6-2.

Table 6-2. Connector Pin Identification

Signal	Data Set	Data Terminal
Transmitted Data	Pin 3	Pin 2
Received Data	Pin 2	Pin 3
Data Set Ready	Pin 20	Pin 6
Data Terminal Ready	Pin 6	Pin 20
Request to Send	Pin 5	Pin 4
Clear to Send	Pin 4	Pin 5
+12VDC (TTY Power)	Pin 11	Pin 11
-12VDC (TTY Power)	Pin 23	Pin 23
+5VDC (Optional)	Pin 25	Pin 25
Common	Pin 7	Pin 7
Protective Ground	Pin 1	Pin 1

SECTION VII

PROM BOARD JUMPER CONNECTIONS

7.0 PROM BOARD JUMPER CONNECTIONS

7.1 ADDRESS SELECTION

The PROM Board address range is selectable via jumper connections on a 14-pin connector as shown in Figure 7.1. The normal address range is 0000 Hex to 1FFF Hex. Table 7-1 shows the jumper connections for both 2708 and 2716 PROMS.

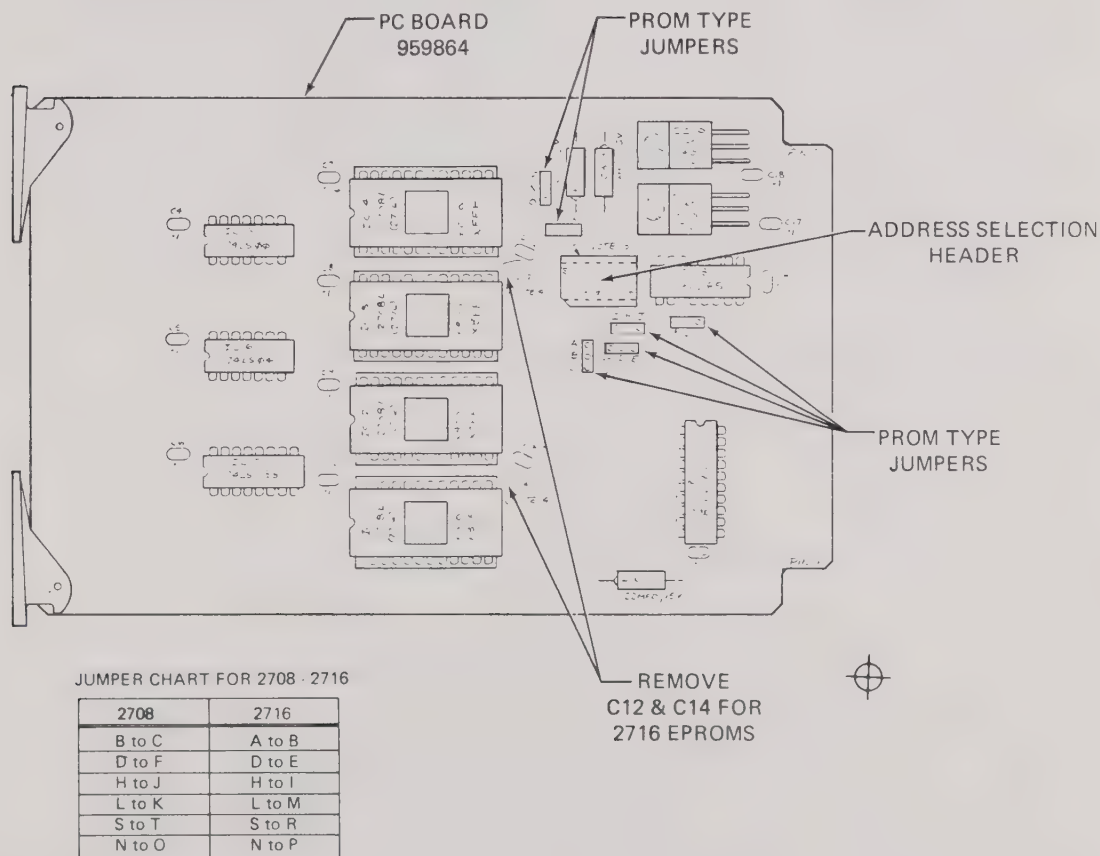


Figure 7.1 - PROM Board Jumper Setup

Table 7-1. Address Selection

2708 PROMS					2716 PROMS				
Address Range (Hex) 4K Block	Connect Pin				Address Range (Hex) 8K Block	Connect Pin			
	1	2	3	4		1	2	3	4
	To Pin					To Pin			
0000 to 0FFF	7	7	7	7	0000 to 1FFF	7	7	7	7
1000 to 1FFF	14	7	7	7	2000 to 3FFF	7	14	7	7
2000 to 2FFF	7	14	7	7	4000 to 5FFF	7	7	14	7
3000 to 3FFF	14	14	7	7	6000 to 7FFF	7	14	14	7
4000 to 4FFF	7	7	14	7	8000 to 9FFF	7	7	7	14
5000 to 5FFF	14	7	14	7	A000 to BFFF	7	14	7	14
6000 to 6FFF	7	14	14	7	C000 to DFFF	7	7	14	14
7000 to 7FFF	14	14	14	7	E000 to FFFF	7	14	14	14
8000 to 8FFF	7	7	7	14					
9000 to 9FFF	14	7	7	14					
A000 to AFFF	7	14	7	14					
B000 to BFFF	14	14	7	14					
C000 to CFFF	7	7	14	14					
D000 to DFFF	14	7	14	14					
E000 to DFFF	7	14	14	14					
F000 to FFFF	14	14	14	14					

7.2 PROM TYPE SELECTION

Either 2708 (1Kx8) or 2716 (2Kx8) EPROM's may be used in the PROM board. Six on-board jumpers (see Figure 7.1) select the PROM type as follows:

- 2708 - Put all 6 jumpers in the "08" position
- 2716 - Put all 6 jumpers in the "16" position

Important: When 2716 EPROM's are used, remove capacitors C12 and C14 as shown in Figure 2.1.

SECTION VIII

PROPORTIONAL BAND, RESET AND RATE

8.0 DISCUSSION OF PROPORTIONAL BAND, RESET AND RATE

The following discussion is intended to clarify the above control parameters used in precision control applications.

8.1 PROPORTIONAL BAND

The proportional controller is one which makes a simple correction in its output (and thus in power to the process) which depends on the magnitude and the direction of the error which it "sees". A proportional controller with a span of 0-1000°C and a proportional band of 100°C would operate as follows:

Assume the initial adjustments and conditions are such that the process is operating at 500°C and the power applied to the furnace is 50% of that available. Under these conditions, a temperature rise in the furnace to 525°C would reduce applied power to 25%; a temperature drop to 490°C, the power would increase to 60% - - - proportional band calibration normally refers to the input error measured in degrees which is required to "full-stroke" the controller output.

If we assume the same initial conditions and change the PB to 50°C, it will take only a 50°C error to swing the controller through its range and, should the furnace temperature rise to 525°C, the output would be reduced to zero. If the temperature should drop to 490°C, the power would increase 20% over the initial value of 50%.

Now, with the same process, if we reduce the PB to 5°C, the power will be off at 502.5°C and full on at 497.5°C (note that this represents 100% change in controller output with a 5°C change in temperature).

With a 1°C PB, the power would be full on at 499.5°C and full off at 500.5°C --- a controller with a 0°C PB is an on-off controller.

Next, note that a temperature error is required to make a change in controller output and thus power to the furnace. In the first example, if the furnace load has been changed so that 100% power would be required to hold 500°C, the process would have "gone cold" maybe 25°C while the power increased about 25%. WITH PROPORTIONAL ONLY CONTROL, THE ERROR MUST REMAIN IN ORDER TO MAKE A PERMANENT CHANGE IN CONTROLLER OUTPUT. Narrower proportional bands will produce less offset (error) with load or temperature changes but will cause uncontrolled cycling if there is any lag in the measurement.

- 8.2 Reset. (Integral) A resetting controller is a "floating" controller. So long as the process is cold, the process power will increase at a rate depending on the magnitude of the error and the setting of the Proportional and Reset adjustments. So long as the process is hot, power will be reduced in the same manner. Reset is the automatic control function that corrects for load changes on the process. Its operation is as follows:

Assume that we have the process we discussed in the previous example; 500°C schedule, power 50% on, PB at 100°C, and RESET at 1.0 RPM (Repeat per Minute). With the resetting controller, the load change which allowed the temperature to go to 525°C would reduce the power to 25% by proportional action just as it did before but now the power would continue to decrease at the rate of 25% per minute so long as the temperature remained at 525°C. The RESET action is repeating the power reduction produced by proportional action once per minute. RESET REPEATS PROPORTIONAL ACTION AT A SPEED DETERMINED BY THE RESET DIAL SETTING.

Now assume that the process begins to cool due to the reduction in power. As the process cools toward 500°C (our assumed setpoint), proportional action will add 1% power for each degree of cooling while the reset continues to reduce power. By the time the process had dropped to 510°C, the proportional action would have added 15% power, reset would have subtracted power depending on how long the process had been hot and would, at 510°C, be reducing power at the rate of 10% per minute. When the process dropped to 505°C, proportional control would have added another 5% and reset would be reducing power at 5% per minute; at 501°C, proportional control would have added another 4% while the reset action would still be reducing power at 1% per minute.

Finally, the process will come back to schedule and proportional and reset modes will become inactive....but the nominal power level on the furnace will no longer be 50%. Since proportional action will have added the same 25% of power it had removed when the process was hot, it contributes nothing once the process is back on schedule. Reset action, on the other hand, will have continued to reduce power for the total time the process was above schedule and this accumulated reduction will provide the new "steady-state" power required to hold the process at its scheduled 500°C. This process is similar to storing charge on a capacitor.

- 8.3 Rate. (Derivative) Rate action is a special control function which is intended to make immediate corrections in process power when load changes occur. Unlike Proportional and Reset mode, no appreciable error is required to make appreciable changes in process power. Rate provides a powerful stabilizing force and is equally effective in compensating for changes in line voltage, ambient temperatures, schedule changes, etc.

Rate action, like Reset action depends on the proportional setting. In the case of Rate, however, the controlling variable is the "rate" at which the temperature is changing. Let us return to our example except, instead of a step change in the process temperature, let us assume that the temperature starts increasing at 5°C per minute and we have set 5 minutes of rate time into the controller. In this instance, proportional control would start reducing power at the rate of 5% per minute while rate action would make an immediate 25% reduction in process power and would maintain this 25% reduction so long as the temperature continued to rise at 5°C/min. Note that this 25% reduction in power is the same correction which would have occurred due to proportional action had the error continued for FIVE MINUTES.

As soon as the rate of temperature change diminished, the effect of rate action diminishes; when the temperature rise is reduced to 4°C/minute, rate action will maintain a power reduction of on 20%. When the temperature has stoped rising rate action is reduced to zero even though the actual process temperature is considerably above the control point. When the temperature has turned around

and starts dropping, rate action adds power even though the process is still above schedule. Thus, rate action makes an immediate change which is intended to oppose any change in the process temperature.

Rate action is a powerful stabilizing force in many control installations though it has not received the use it deserves. When a potentiometric instrument (Recorder-Controller) is used, the error signal is obtained from a slidewire and this error signal often consists of a series of "steps" as the slidewire contactor moves from one convolution to the next. These steps in error signal can represent very large rate signals and produce serious controller upsets. The modern solid-state controls, on the other hand, produce very smooth error signals and rate action can operate as it is mathematically intended.

The calibration of the Rate mode of control is in MINUTES and may be defined as follows:

Rate action will make an instantaneous correction in controller output which is equivalent to that which Proportional Control would have made and the rate of error continued for the time setting of the rate.

SECTION IX

SPECIFICATIONS AND ORDERING INFORMATION

9.0 SPECIFICATIONS AND ORDERING INFORMATION

9.1 SPECIFICATIONS

9.1.1 Thermocouple Input. (3 wire shielded input) All standard NBS listed thermocouples, J, K, R, S, and Platinel II. Linearized to $+1^{\circ}\text{C}$ for J, K, Platinel II and $+2^{\circ}\text{C}$ for R, S. Cold Junction compensation to $+1^{\circ}\text{C}$ over $0-60^{\circ}\text{C}$ change in ambient.

9.1.2 Thermocouple Break Protection. Upscale break protection is standard.

9.1.3 Source Resistance. 0 to 1000 ohms with no change in calibration.

9.1.4 Outputs. 0-5 VDC or 0 to 10 VDC into 1 kohm or higher

4-20mA into 0 to 700 ohms

Open collector time proportioning, 3 sec time base, 20mA max (Ideal for optical solid state relay)

9.1.5 Sample Time. Two samples per sec. (Total sample time for 16 channels is 8 sec.)

9.1.6 Reset Windup Inhibition. Inhibits reset action when deviation is outside of proportional band.

9.1.7 Rated Operating Conditions

Ambient Temperature:	0 to 55°C
Input Power Supply:	120 or 240 VAC $\pm 15\%$ 50/60Hz, 35 VA
Humidity:	0 to 80% RH (non-condensing)
Common Mode Rejection:	110 db
Maximum Common Mode Voltage:	120 VAC

9.1.8 Accuracy $\pm 1^{\circ}\text{C}$ with $\pm 15\%$ change in line voltage

9.1.9 Power Consumption. 35VA (max with all cards)

9.1.10 Process Variables Storage. Variables stored in CMOS memory with Nicad battery backup. 500 hr. retention from fully charged batteries.

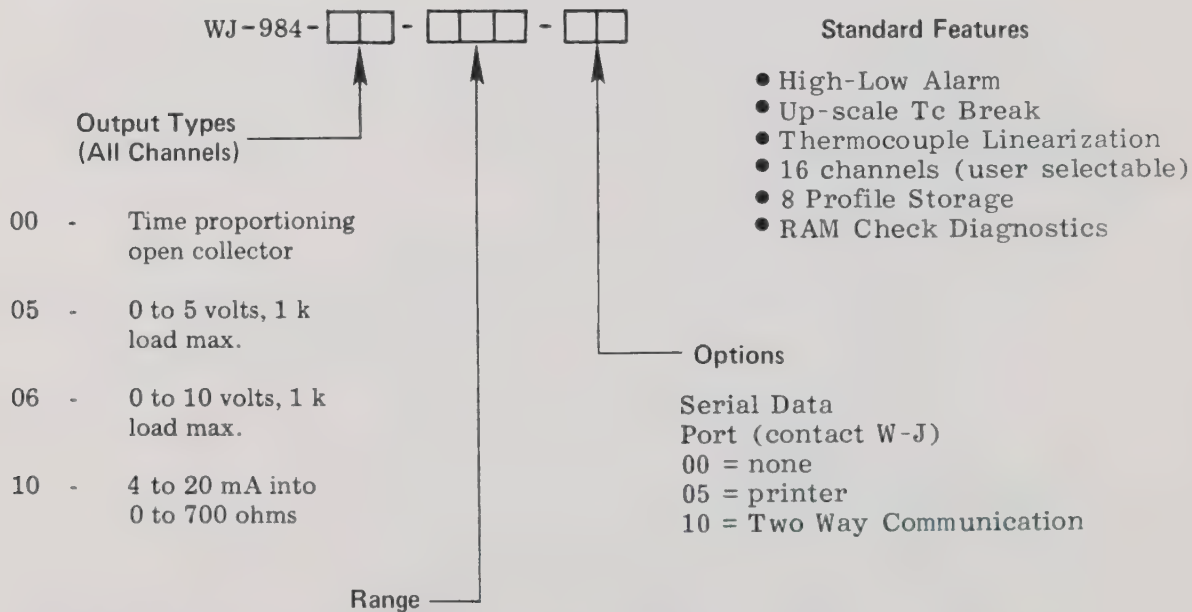
9.1.11 Tuning Constants

Proportional Band:	1°C to 99°C
Reset:	0.1 to 9.9 repeats/min.
Rate:	0.1 to 9.9 minutes
Maximum Power:	0 to 99%
High and Low Limits:	0 to 1999°C

- 9.1.12 High-Low Limit Alarm Outputs. Two SPDT Relays (one for high, one for low), 1 A at 20VDC or 0.5A at 120VAC resistive.
- 9.1.13 RS-232 Serial Port. Data set or data terminal (jumper selectable) see W-J Specification #984-1 for full details.
- 9.1.14 Signals Supported

Signal	Data Set	Data Terminal
Transmitted Data	Pin 3	Pin 2
Received Data	2	3
Data Set Ready	20	6
Data Terminal Ready	6	20
Request to Send	5	4
Clear to Send	4	5
Common	7	7
+12 (Power for optional)	11	11
-12 20mA current loop	23	23
+5 adapter	25	25

9.2 Ordering Information



PART #	THERMOCOUPLE TYPE	RANGE
007	"K" Chromel-Alumel	0-1200°C
010	"K" Chromel-Alumel	0-600°C
015	"J" Iron - Constantan	0-600°C
011	"R" Plat - Plat 13°C RH	0-1700°C
012	"S" Plat - Plat 10°C RH	0-1700°C
008	Platinel II	0-1200°C

Other Ranges on Request

SECTION X

SPARE PARTS LIST

10.0 SPARE PARTS LIST

The following PC Boards are stocked at Watkins-Johnson and may be purchased for replacement of faulty boards or as spare parts. Always note the controller serial number and part number on any orders.

<u>Description</u>		<u>Part Number</u>
1.	CPU Board	959861
2.	PROM Board (note 1)	959865
3.	RAM Board	962602
4.	Auxiliary Board	959909
5.	Input Board (note 2)	959881
6.	Output Board (note 3)	961113
7.	RS-232 Board (note 4)	961123
8.	Front Panel Board	959941
9.	Power Supply Assembly	959891
10.	High/Low Alarm Board	962882

Note 1: When ordering the PROM board specify the program code located on the PROM chips (i.e. 030, 060, etc.)

Note 2: When ordering the Input board specify the thermocouple type. ("K", "R", "S", etc.)

Note 3: When ordering the Output board specify the output type:
1. 0-5V or 0-10V
2. 4-20mA
3. time proportioning

Note 4: The RS-232 board is shipped in the "Data Terminal" configuration. See Section 6 for jumper setup for the "Data Set" configuration.

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Appendix A

"FUNCTION" KEY OPERATION

SCOPE

The "FUNC" or function key of the front keyboard allows the user to perform the other operations besides the normal data entry for temperature control. When the "FUNC" key is depressed, an "F-" prompt appears on the channel display asking the user to enter the desired function number. At the time of this writing the following functions had been incorporated. (Note: On early controllers the "FUNC" key was called the "INIT" key.)

<u>Function</u>	<u>Description</u>
F1	<u>Profile Recall</u> - Allows the user to recall any one of 8 profiles (sometimes called recipes) that have been stored in memory using function 2. See Appendix B for complete description.
F2	<u>Profile Store</u> - Allows the user to store a current set of operating parameters in memory. Up to 8 different profiles can be stored. All data is protected for up to 500 hours in the event of a power failure. See Appendix B for complete description.
F3	<u>Time, Date, Cycle</u> - Used with line printer (option 05). This function allows entry of the time, date and a printer cycle time. Appendix C has a complete description.
F4	<u>Ram Memory Test</u> - Function 4 does a write - read - compare check on the Ram memory. If a bad memory location is found, the address (in hexadecimal) is displayed on the front panel. If the test is passed the "CH" prompt appears signifying return to the enter data mode of operation. The Display is blank for about 1 minute during the test.

Appendix B

PROFILE RECALL and STORE (Function 1 and 2)

SCOPE

Up to 8 different profiles (or recipes) can be recalled and stored using Function 1 and 2. This saves the operator considerable time when multiple profiles must be used within a single oven. Function 2 allows the user to store a profile which may later be recalled using Function 1.

The controller memory is divided up into 8 buffer area's which are used to store profiles. In addition there is an operating buffer which contains the current set of operating conditions that the controller is actually processing. When a profile is stored, it is merely transferred from the operating buffer into one of the eight storage buffers. An important point here is that the profile still remains in the operating buffer, after a store is performed.

Another important point is that, initially, the storage buffer area is empty. Profiles must be entered through the keyboard into the operating buffer and then stored using Function 2 before they can be recalled. Trying to recall a profile that doesn't exist loads garbage into the operating buffer and results in indeterminate controller action.

The procedure for storing and recalling is as follows:

	Action	See Displayed		Remarks
1.	Turn keyswitch to "ENTER DATA" mode.	CH		Channel number prompt appears.
2.	Press "FUNC" Switch	F-		Now in Function mode.
3.	Enter function number 1 = profile recall 2 = profile store	F2		Function 2- profile store
4.	Press "ENTER" key	F2	P-	Profile number prompt appears
5.	Enter the desired recipe number (1 to 8) for the profile to be recalled or stored under.	F2	P6	Store current profile as profile #6.
6.	Press "ENTER" key	CH		Data is stored as profile #6 Channel # prompt appears.

The above example illustrates the procedure for storing a profile using "F2". To recall a profile the procedure is the same except "F1" or Function 1 is used.

Appendix C

LINE PRINTER OPERATION (Option 05)

1.0 SCOPE

Option 05 is a program designed to record data on an 80-column alphanumeric printer, or any other RS-232 compatible recording device. This option requires that the controller be fitted with an RS-232 circuit board (WJ assy #961123) and its associated 25-pin "D" connector. Data is transmitted at 300 BAUD, 7 Bits, even parity with one start bit and 2 stop bits. All data is in ASCII format. The RS-232 port can be configured as either a "Data Set" or a "Data Terminal" to accommodate various types of recording devices. See Section for further details. A typical printer output is shown in Figure C-1. Notice that in addition to printing the current controller operating parameters, the time and date are also printed. These parameters as well as a print cycle time are entered through the keyboard under "Function 3". (See Appendix A).

2.0 ENTERING TIME, DATE, AND PRINT CYCLE

The following procedure is used to enter the time, date, and print cycle.

	Action	See Displayed		Remarks
1.	Turn Keyswitch to "ENTER DATA" position	CH		Controller is in "enter data" mode.
2.	Press "FUNC" key	F-		Controller is in "Function" mode
3.	Press 3 for Function 3 (Time mode)	F3		Function 3
4.	Press "ENTER" key	A	XX.XX	Current time (initially 00.00) A = AM P = PM
5.	Alternately pressing "STEP DATA" changes between AM and PM	A P	XX.XX XX.XX	XX.XX = current time
6.	Enter time through keyboard to the next highest minute (i.e. 12:35:16 = 12:35)	P	12.36	12.36 PM

THE TIME IS 02:45 PM

DATE: 11/4/77

CHAN	TEMP	DEV	SP	ZPWR	MAXP	HLIM	LLIM	FE	RESET	RATE
1	23	- 177	200	45	45	1150	0	50	0.1	0.5
2	23	- 177	200	45	45	1150	0	50	0.1	0.5
3	23	- 197	220	45	45	1150	0	50	0.1	0.5
4	23	- 197	220	45	45	1150	0	50	0.1	0.5
5	23	- 227	250	45	45	1150	0	50	0.1	0.5
6	23	- 227	250	45	45	1150	0	50	0.1	0.5
7	23	- 227	250	45	45	1150	0	50	0.1	0.5
8	23	- 267	290	60	60	1150	0	50	0.1	0.5
9	23	- 267	290	60	60	1150	0	50	0.1	0.5
10	23	- 267	290	60	60	1150	0	50	0.1	0.5
11	23	- 302	325	60	60	1150	0	50	0.1	0.5
12	23	- 302	325	60	60	1150	0	50	0.1	0.5
13	23	- 327	350	75	75	1150	0	50	0.1	0.5
14	23	- 327	350	75	75	1150	0	50	0.1	0.5
15	23	- 347	370	75	75	1150	0	50	0.1	0.5
16	23	- 347	370	75	75	1150	0	50	0.1	0.5

THE TIME IS 02:46 PM

DATE: 11/4/77

CHAN	TEMP	DEV	SP	ZPWR	MAXP	HLIM	LLIM	FE	RESET	RATE
1	23	- 177	200	45	45	1150	0	50	0.1	0.5
2	23	- 177	200	45	45	1150	0	50	0.1	0.5
3	23	- 197	220	45	45	1150	0	50	0.1	0.5
4	23	- 197	220	45	45	1150	0	50	0.1	0.5
5	23	- 227	250	45	45	1150	0	50	0.1	0.5
6	23	- 227	250	45	45	1150	0	50	0.1	0.5
7	23	- 227	250	45	45	1150	0	50	0.1	0.5
8	23	- 267	290	60	60	1150	0	50	0.1	0.5
9	23	- 267	290	60	60	1150	0	50	0.1	0.5
10	23	- 267	290	60	60	1150	0	50	0.1	0.5
11	23	- 302	325	60	60	1150	0	50	0.1	0.5
12	23	- 302	325	60	60	1150	0	50	0.1	0.5
13	23	- 327	350	75	75	1150	0	50	0.1	0.5
14	23	- 327	350	75	75	1150	0	50	0.1	0.5
15	23	- 347	370	75	75	1150	0	50	0.1	0.5
16	23	- 347	370	75	75	1150	0	50	0.1	0.5

Figure C-1

Appendix C (Continued)

	Action	See Displayed		Remarks
7.	Depress "ENTER" key when seconds reach 60	d1	XX	When "ENTER" key is pressed the time is stored and the date mode is activated. d1 = month d2 = day d3 = year
8.	Enter the month (i.e. 11 = Nov) and press "ENTER" key	d1	11	month = Nov
9.	"d2" prompt for day appears	d2	XX	
10.	Key in day and press "ENTER"	d2	4	Nov 4
11.	"d3" prompt for year appears	d3	XX	
12.	Key in year and press "ENTER"	d3	79	Nov 4, 1979
13.	Date is now stored and cycle prompt appears	C	XX	C = cycle time in minutes
14.	Press "STEP DATA" key to select cycle time	C	XX	Available cycle times are: 1, 2, 3, 4, 5, 10, 12, 15, 20, 30, and 60 minutes
15.	Press "ENTER" key to activate the displayed cycle time	A	XX.XX	Controller returns to display current time.
16.	Press "FUNC" key to return to enter data mode or turn keyswitch to scan position if complete.			

Appendix C (Continued)

3.0

GENERAL NOTES ON TIME-DATE-CYCLE MODE

1. Pressing "FUNC" key exits the time mode and returns to the normal enter data mode.
2. The "STEP CHAN" key may be used to step between time, data, and cycle time for selective entry of data.
3. The "STEP DATA" key steps between dates (i.e., d1, d2, d3) for selective date entries.
4. Values entered through the keyboard do not go to memory until the "ENTER" key is pressed.
5. With the key switch in the "SCAN" position, pressing the "ENTER" key will activate a print cycle regardless of the cycle time. This gives the user a print on command function.

Appendix D

TWO-WAY COMMUNICATION PROTOCOL (OPTION 010)

1.0 SCOPE

Option 010 provides a software and hardware package that allows two-way communication with the temperature controller from an external RS-232 compatible device. The hardware consists of the Prom program memory chips, an RS-232 PC board and a 25-pin "D" type connector and cable. In addition, an optional optically coupled current loop adapter is available for 20 mA current loop operation.

The Baud rate is selectable by the setting on the lower BCD switch of the auxiliary PC board. (See Section 2.2.6 and 5.2.4) Selection is from 110 baud to 9600 baud. Transmission is asynchronous via ASCII characters with 1 start bit, 7 data bits, 1 parity bit (even) and 2 stop bits. Optional modes are available upon request.

2.0 COMMUNICATION PROTOCOL

Single letter ASCII commands are used to communicate with the controller. All commands are terminated with a carriage return (CR). Commands and data are echoed back and in addition to the CR a line feed (LF) is also added. This facilitates CRT operation. Spaces are ignored but are echoed back.

3.0 COMMAND SYNTAX (Items between " " are the actual commands)

The following commands are available for external communication with the controller.

"R" Command - The "R" (reset) command causes a jump to the starting point of the controller program. The main use of this command is to reset the controller after a high or low limit alarm has been activated. It is also useful as a "software" reset if a malfunction is detected. The syntax is "R CR".

"K" Command - The "K" command is used to check the status of the front panel key switch for either the Enter Data or Scan mode. Upon execution this command returns an "E CR LF" to signify the enter data mode or an "S CR LF" to signify the scan mode. This command will tell an external device if the controller is being accessed locally. The syntax is "K CR".

"S", "B", "P", "H", "L", "I", and "D" Commands - These commands are for changing the setpoint, proportional band, maximum power, high limit, low limit, integral (reset), and derivative (rate), respectively. For a complete description of these functions see Section 2.1.3 and 8.

A syntax example for the "S" or setpoint command is: "S1, 300, 1100, 400 CR". In this example the setpoint for channel 1 is changed to 300°C, channel 2 to

Appendix D (Continued)

1100°C and channel 3 to 400°C. The channel number (in this case 1) can be from 1 to the maximum for the instrument. As many values can be added between comma's as desired, but if the number of values exceeds the maximum number of channels, then the beginning channels will be overwritten. Illegal channel numbers or control values will result in a "? CR LF" response from the controller. Examples of legal and illegal commands are:

	Command	Response
legal	"S3, 600CR"	Change channel 3 setpoint to 600
legal	"H3, 300, 600, 900 CR"	Change channel 3 high limit to 300, change 4 to 600, change 5 to 900.
illegal	"P18, 80 CR"	Channel number is too large. Controller sends "? CR LF"
illegal	"S10, 1300 CR"	Setpoint is too large (1199 max for type K thermocouple, 1699 max for type R thermocouple)
illegal	"B6, 0 CR"	Proportional Band of zero is not allowed. Minimum is 1°C.

Decimal points are optional for integral and derivative entries. For example, "I1, 3.6 CR" and "I1, 36 CR" are considered the same. The maximum values for integral and derivative are from 0.1 to 9.9.

"T" Command - The "T" (type) command will return controller data to the originator. The Syntax is: "T chan# - chan# CR". The first channel number must be smaller than the second channel number and both numbers must be smaller than the maximum number of channels. The second channel number is optional. Syntax examples are: "T1-3CR" and "T6CR". A typical output for the above commands is shown in examples 1 and 2. Data is separated by ASCII spaces (0x20) which can be used to sense values by an external computer.

Example 1: "T1-3CR"

CHAN	TEMP	DEV	SP	%PWR	MAXP	HLIM	LLIM	PB	RESET	RATE
1	XXXX	SXXXX	XXXX	XX	XX	XXXX	XXXX	XX	X.X	X.X
2	XXXX	SXXXX	XXXX	XX	XX	XXXX	XXXX	XX	X.X	X.X
3	XXXX	SXXXX	XXXX	XX	XX	XXXX	XXXX	XX	X.X	X.X

Example 2: "T6CR"

CHAN	TEMP	DEV	SP	%PWR	MAXP	HLIM	LLIM	PB	RESET	RATE
6	XXXX	SXXXX	XXXX	XX	XX	XXXX	XXXX	XX	X.X	X.X

7.0 OTHER FEATURES

- o Any command may be terminated by sending the "ESC" character (01B Hex).
- o When the controller is waiting for a command it issues an ">" prompt to notify the user.
- o When an error is detected an "?CR LF" is sent followed by an ">" prompt for a new command.

Appendix E

IDLE PROFILE FEATURE

The Idle Profile feature allows automatic switching between two separate profiles for such applications as power saving during weekends. Normally a seven day timer is connected to the "IN" terminals of the Alarm PC Board (see Figure 2.14) to activate the two profiles. When the timer switch closes (usually during weekend periods) the controller will automatically load profile #8. Of course, profile #8 must be preloaded using the profile store-recall feature described in Appendix B. When the timer switch opens again, the controller will load the profile number that is designated by the BCD switch which is second from the bottom on the auxiliary board (see Figure 5.5). For example, if this switch were set at "2", profile #2 would be loaded when the timer switch opened. This system allows the user to be operating on say profile X, switch to profile Y (always #8) during the weekend, and return to the same profile. The profile, however, must be preloaded into a memory slot using function 2 and the BCD switch must be set to that number. Once the desired profiles are stored in memory (up to 8), the user simply has to change the BCD switch to the desired profile to activate a different profile when the timer switch opens.

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